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U. S. DEPARTMENT OF AGRICULTURE

BIOLOGICAL SURVEY--BULLETIN No. 30

C. HART MERRIAM, *Chief*

BIRDS OF CALIFORNIA

IN RELATION TO THE
FRUIT INDUSTRY

PART I

By F. E. L. BEAL

Assistant, Biological Survey

WASHINGTON
GOVERNMENT PRINTING OFFICE
1907

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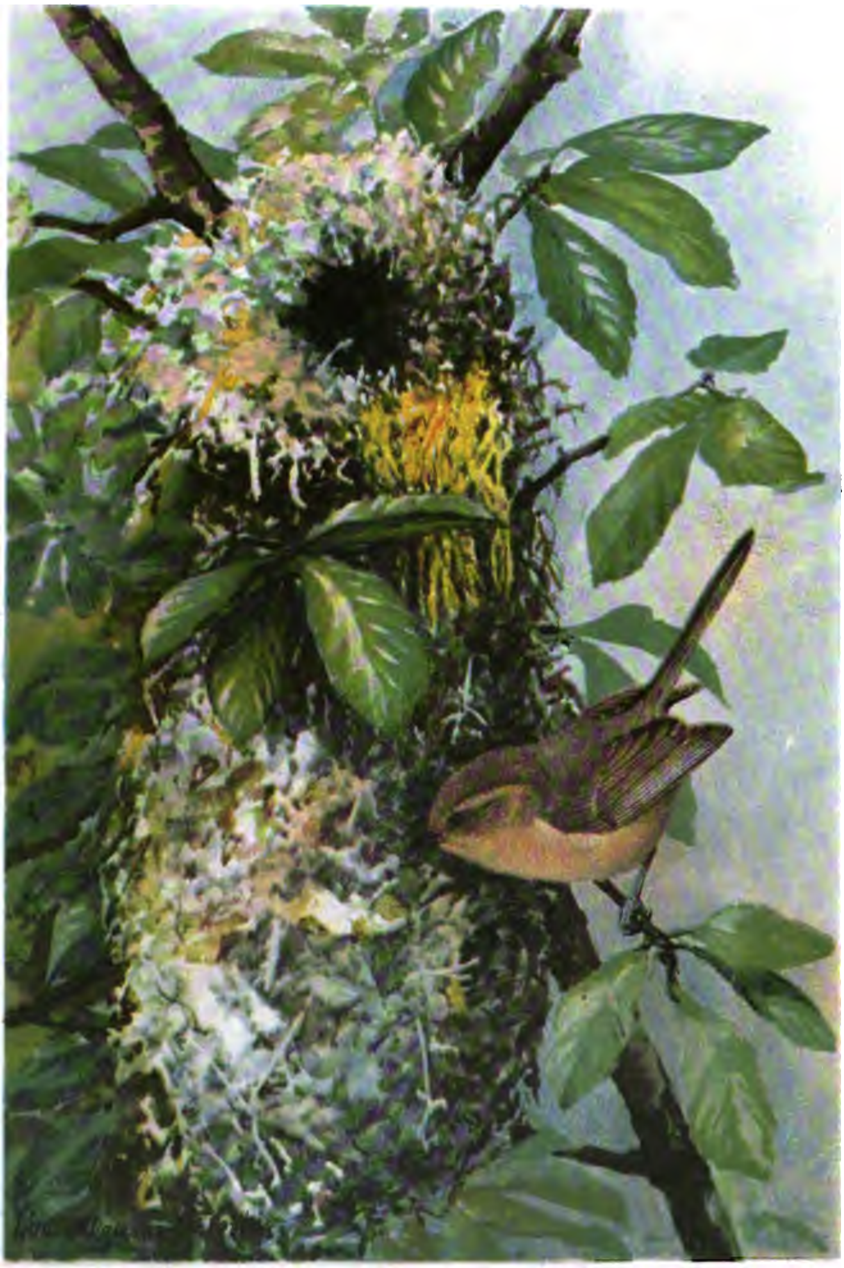

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CALIFORNIA BUSH-TIT (PSALTRIPARUS MINIMUS CALIFORNICUS).

Issued November 11, 1907.

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1907

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., July 27, 1907.

Sir: I have the honor to transmit herewith as Bulletin No. 30 of the Biological Survey, Part I of a report on the Birds of California in Relation to the Fruit Industry, by F. E. L. Beal. Fruit raising in California is a great and growing industry, and the relation birds bear to it is important. The investigations embodied in the present report were undertaken with a view to the accurate determination of the economic status of every species of California bird that inhabits orchards, in order that it may be possible for the fruit raiser to discriminate between friends and foes; and for the added purpose of suggesting remedial measures for the protection of fruit from destructive species. As expected, the strictly insectivorous birds prove to be almost wholly beneficial, by far the greater percentage of the insects eaten by them being injurious kinds. They are hence allies of the orchardist and their presence in and near orchards should be encouraged in every way. Of the species addicted to fruit eating, not one was found to make its diet wholly, or even chiefly, of fruit; and the fruit eaters, with possibly the exception of the house finch, are found to feed upon weed seeds and noxious insects to such an extent as to fully offset their destructive propensities.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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BIRDS OF CALIFORNIA IN RELATION TO THE FRUIT INDUSTRY--PART I.

INTRODUCTION.

In response to numerous complaints from fruit growers concerning depredations by birds in orchards and vineyards in the Pacific coast region, investigation of the subject was undertaken by the Biological Survey several years ago. In conducting this investigation the writer spent about nineteen months in California, including the fruit seasons of 1901, 1903, and 1906, during which time he visited the most important fruit-growing regions of the State, inspected hundreds of orchards, and interviewed many fruit growers. Kindness and courtesy were everywhere met with, and every facility was extended by orchardists for the acquisition of information, even to a suspension of the customary rules with regard to trespass and shooting on private grounds. In addition to the knowledge gained by field observations, stomachs of all the species of Pacific coast birds economically valuable have been collected, examined, and their contents recorded.

When depredations are so widespread and involve so many different species of birds, a thorough knowledge of the nature and extent of the damage done and of the attending circumstances is of great importance. Next in importance is a knowledge of the conditions that obtain in fruit-growing regions where depredations by birds do not occur. This information should enable the fruit grower to adjust conditions in his own case so as to mitigate if not wholly prevent the evil.

In the following pages much stress is laid on the nature of the yearly or seasonal food of some of the more important species of birds, since it often happens that certain birds are more or less harmful to a particular crop of fruit, and yet the year through, all things considered, do more good than harm. It must not be forgotten in this connection that there are very few birds whose habits are wholly beneficial. Most of them are neither wholly beneficial nor wholly injurious. They are beneficial at some seasons and injurious at others. In some localities they are deservedly praised for benefits conferred; in others the same species are condemned for destructive habits. With the evidence all in, it is usually possible for the farmer to properly estimate the status of any given species with reference to his own farm and his own interests and to adopt measures accordingly.

It can not be too thoroughly insisted that sound public policy everywhere forbids the destruction of birds on a large scale for the purpose of protecting orchard fruits. Wholesale slaughter of birds in the supposed interest of the orchardist is fortunately rare and often proceeds from a mistaken idea of their economic relations. When it is understood that the damage by a certain species is local and exceptional, that the birds in question are on the whole beneficial and that their destruction will be a loss to the State, the farmer and the orchardist are usually willing to adopt less drastic measures in defense of their crops and to spare the birds for the sake of the general weal.

STATUS OF BIRDS IN NEWLY SETTLED REGIONS.

When a new country is settled, large areas are plowed and brought under cultivation. In the process great numbers of native shrubs, weeds, and grasses are destroyed, and various new and exotic plants and trees are substituted. Coincident with this change in the vegetable life, and as a necessary consequence of it, great changes in the conditions and distribution of animal life take place. Some species are restricted in distribution and greatly reduced in numbers, or even exterminated, while others become more abundant and more widely dispersed. The reduction in numbers may occur from actual killing by man, from the destruction of natural breeding sites through clearing, and from a diminution of food traceable to the same cause. The results are exactly the opposite when cultivation and planting afford a more abundant supply of food, greater facilities for breeding, and better protection from enemies. The natural result of such conditions is a marked increase in number of the favored species, and this increase probably explains the great devastation of crops by birds that occurred on the Atlantic seaboard soon after the first settlements, and then successively in the States to the westward as these were gradually settled.

The early days of agriculture in California offer an interesting case in point. When the native grasses and weeds of the fertile valleys were destroyed to make room for grain, many species of birds, notably blackbirds and quails, were suddenly deprived of their natural subsistence and in place of it were supplied with an abundance of new and nutritious food. Naturally they preferred the cultivated grains (wheat, barley, and oats) to the wild oats (*Avena fatua*) upon which they had largely depended. Still later, when many of the grain fields gave way to extensive orchards, which gradually crept up the hillsides and into the canyons, other species of birds began to utilize the new kinds of food and also the safe nesting sites afforded by orchard trees. Species that previously attracted little attention soon increased in numbers because of the increased food supply, additional facilities for nesting, and the protection afforded by man, who killed or drove away their natural enemies. As a result, some of them suddenly became of great economic importance, owing to their increased numbers and destructive habits.

MIGRATION OF BIRDS.

Owing to its extent and varied topography, California is rich in birds, both in species and individuals. Here altitude and topography, as well as latitude, govern climate. This fact leads to many peculiarities in distribution and complicates the study of birds in their economic and other relations. The movements of birds, too, are more complex than in the eastern part of the United States. The regular migration north in the spring and south in the fall, which is the rule over the greater part of the country, is here supplemented, in the case of many species, by a migration from the mountains, where they breed, to the valleys, where they winter. Besides the regular migrations, at times remarkable incursions of a single species take place. Such was the flight of mountain tanagers (*Piranga ludoviciana*) in the valleys in May, 1896. In several parts of California these birds appeared in immense numbers in localities where previously they had been rarely observed. Their appearance coincided nearly with the ripening of the cherry crop, to which in some places they did much damage in spite of the fact that great numbers of them were shot.

CAUSES OF DEPREDATIONS BY BIRDS.

The failure of customary food supply sometimes leads birds to forage upon crops which they do not commonly eat. This may be the explanation of the depredations of robins in the fall and winter of 1900–1901, when thousands of these birds pillaged the olive orchards in Santa Clara Valley, the region about Santa Barbara, and other parts of California. In that year it was as much as the olive growers could do to save part of their crop. Since then no case of excessive loss of olives has been reported, though occasionally some damage has been done.

The amount of damage inflicted by birds upon a crop often depends upon the surroundings. In the case of orchards in the midst of a treeless plain depredations are mostly confined to such birds as nest in them, but they may be visited and damaged by others during migration. On the other hand, fruit grown near or in brushy canyons or on wooded hills is taken by birds that live in such places; or a stream flowing through a region of orchards may harbor in the shrubbery on its banks many birds that do not live in the orchard itself.

Hence depredations by birds may arise: (1) From the settlement of a region and consequent introduction of new crops, accompanied by a diminished supply of natural food, destruction of enemies, and a general change of natural conditions; (2) from failure of the normal food supply, causing migration in search of food, or an attack upon some product which the species does not usually eat; (3) from proximity to a particular crop, in which case the bird naturally eats that which is most available.

CONDITIONS IN CALIFORNIA COMPARED WITH THOSE IN THE EASTERN STATES.

Before proceeding to a consideration of particular birds, one point should be specially noted in connection with the subject of the relation of birds to fruit in California. Those parts of the State where fruit is grown are not so well supplied with wild fruits on which birds feed as are the fruit-growing areas of the Eastern States, or even of those farther north on the Pacific coast. While California has an abundance of wild berries which serve as food for birds, they do not commonly grow near orchards and vineyards.

In the Eastern States a plentiful supply of fruit, as acceptable to birds as the best products of the orchard or garden (perhaps more acceptable), is usually present in pastures and along roadsides, so that it is only where wild fruits are exterminated by cultivation that birds are forced to eat cultivated kinds. So abundant is wild fruit in some regions, as in the United States east of the Alleghanies, that it is safe to say that thousands of bushels of blackberries and raspberries which grow wild everywhere annually fall to the ground and rot, in spite of the fact that great quantities are gathered and eaten by man as well as by birds. The same is true of blueberries (Vaccinium) and huckleberries (Gaylussacia), which are so abundant in a wild state that in their season they appear in the markets of most of the cities and large towns, and are eaten in every country home in the region where they grow. In addition to these are several species of dogwood (Cornus), holly (Ilex), cherry (Prunus), Viburnum, and many others, all of which are freely eaten by birds.

Although many of these fruit-bearing shrubs are represented in California by related species, they usually grow in the mountains remote from fruit-growing districts. In fact, the elderberry (Sambucus), the introduced pepperberry (*Schinus molle*), and an occasional mistletoe berry are the only important uncultivated fruits that appear in the stomachs of California orchard birds. On the other hand, in the Eastern States more than 40 species of wild fruits have been found in the stomachs of a single species—the Eastern robin. In the general dearth of wild fruits on the horticultural areas of the Pacific coast it is not surprising that when domestic fruits were first cultivated there the birds gave them a warm welcome, and the orchardist's crops suffered accordingly.

Another reason why birds attack fruit in California more than in the regions farther east is the dryness of the summers, juicy fruits proving an acceptable substitute for water. To secure enough water for their necessities California birds must often fly several miles, while in the Eastern States localities are few in which water can not be obtained within a few rods. In confirmation of the theory that in attacking fruit liquid for slaking thirst is sought by birds as much as food, it may be stated that much of the injury done to small juicy fruits in California, such as grapes and cherries, consists of simple punctures in the skin, through which apparently nothing but juice has been drawn.

PROTECTIVE MEASURES.

It would appear most desirable that some of the available fruit-bearing trees, the fruits of which are of little or no value to man, but which to birds are even more acceptable than cultivated kinds, should be freely introduced into California for the protection of the orchardist. That some of them would thrive there hardly admits of doubt. *Morus alba*, the Russian mulberry, is one of the best, the fruit having little value unless as food for birds. All fruit-eating species are fond of it. Both the red and the black mulberries are equally sought after, but are not often planted for birds alone. The paper mulberry (*Broussonetia papyrifera*) is hardy and is a favorite bird food. Several species of Prunus or cherry, including the choke cherry (*P. virginiana*), and especially its western form (*P. demissa*), the black cherry (*P. serotina*), and the bird cherry (*P. pennslyvanica*) are of great value in protecting fruit crops, birds almost invariably selecting their fruit in preference to the cultivated varieties. There are also several ornamental varieties of cherries, such as the European birdcherry (*P. avium*), *P. pendula* of Japan, and *P. sphærocarpa* of Brazil, which are hardy, the latter in warm regions only, and valuable as bird foods. Both the pepper tree, *Schinus molle*, and the elder, Sambucus, now abundant in California, are eaten by many birds, and both may be planted near orchards with the certainty that they will serve to protect them.

Another measure recommended for the protection of orchard fruit is a supply of water accessible to the birds. Drinking places for birds in every large orchard would tend to reduce the injury done to fruit, and would serve the added purpose of attracting insectivorous birds to the locality. Birds undoubtedly select breeding places with reference to the convenience of food and water, and a constant supply of the latter attracts to the vicinity many desirable species. The insectivorous kinds would more than pay the orchardist for his trouble in their behalf by feeding upon the insects that injure his trees; while fruit-eating species, like the linnet, being able to quench their thirst with water, would not be compelled to resort to fruit for this purpose.

The writer once observed a leaky hydrant situated between two rather extensive areas of orchards. The little pool maintained by the drip of this pipe was almost constantly surrounded by birds which all the time were coming and going, so that the number that visited it each day must have been well up in the thousands. An arrangement for this purpose need be neither elaborate nor expensive, and would serve a useful purpose.

READJUSTMENT OF CONDITIONS.

In relation to the destruction of crops by birds in a comparatively newly planted region, experience everywhere shows that after a time there is a partial readjustment of conditions, so that inroads by birds become much less common or wholly cease. On the Atlantic side of the continent at the present time, with the exception of the ravages of bobolinks in the rice fields of the southeastern coast States, few if any cases are known of the annual destruction of crops by birds, while during the first half of the nineteenth century the several species of blackbirds were a constant menace to grain. Present immunity results from the fact that increased density of population has destroyed the nesting sites and reduced the numbers of some of the most noxious birds. This readjustment of conditions is likely to take place sooner or later in all cases where the balance of nature is disturbed, but in most cases the process may be hastened by the adoption of measures like the ones above mentioned.

DAMAGES BY BIRDS GENERALLY.

Study of a number of cases of serious damage by birds leads to the conclusion that as a rule such damage is due to the concentration of a great number of birds within a limited area, usually of a single species or several closely allied ones. If the birds are seed eaters, they visit the grain fields and leave ruin and destruction in their path; if fruit lovers, they seek the orchard and play havoc with the crop. Instances of this kind are the raids of bobolinks in the rice fields of the southeastern Atlantic coast, of the blackbirds in the grain fields of the Mississippi Valley, and of the linnets in the fruit orchards of California. It is seldom that complaints are made of birds in general; one or a few species are usually the culprits, the reason for which is evident—too many individuals of the same species in one locality eating the same things. But when many species are present in normal numbers, such a variety of tastes is to be gratified that no one kind of food is unduly drawn upon.

BIRDS THAT INJURE FRUIT IN CALIFORNIA.

When a fruit grower in northern California is asked what birds are most injurious to his crops, he almost invariably mentions first the linnet, or house finch; then successively the blackbird, the oriole, the grosbeak, and the thrush. Or, if his ranch is in a narrow valley or canyon, or near wooded hills, he may place the California jay or the quail after the linnet as the next worst enemy to fruit.

The writer is pleased to be able to testify to a healthy state of feeling on the part of the great majority of California fruit growers toward the bird population. While many of them stated that they still suffered loss, none advocated measures for the extermination, or even the material decrease, of birds. The feeling seems to be practically universal that birds as a class, notwithstanding their sins, still do more good than harm. "We can't get along without the birds," was the sentiment voiced by many and really indorsed by all.

HOUSE FINCH.

(*Carpodacus mexicanus frontalis.*)

The house finch, or linnet, has been perhaps the subject of more complaint on the score of destroying fruit in California than all other species of birds together. This bird occurs on the western coast of the United States from Mexico northward to Oregon, and extends eastward to the western edge of the Mississippi Valley. Except in the mountains, it is a resident throughout most of California, but in certain parts of the northern half of the State it disappears for a few months during the winter season. In the southern half and in the warm sheltered valleys of the north it is always present. It is a hardy, vigorous species, well able to take care of itself and maintain its ground wherever it obtains a foothold. It is a prolific breeder, raising several broods in the season, and apparently has no enemy (except man) that exercises any perceptible restrictive influence upon its increase and distribution. It takes kindly to the presence of man, and utilizes his improvements for shelter and food.

DESTRUCTION OF FRUIT.

Observations in orchards show that in the fruit season the linnet is not backward in taking what it considers its share of the crop, and as it spends much of the time there, field observations alone would lead to the conclusion that fruit was its principal article of diet. Examination of the stomach contents, however, proves that such is not the case, and when we find how small is the relative percentage of fruit eaten, it seems strange that its fruit-eating proclivities should have attracted so much attention. But it must be borne in mind that the bird is wonderfully abundant, which is one of the primary conditions necessary for any species to become injurious.

Like most fringilline birds, the linnet has a strong, conical beak, with which it can cut the skin of the toughest fruit and reach the pulp. While such an instrument is very effective in attacking fruit, this is evidently not the use for which nature primarily designed it. It is customary to divide passerine birds roughly into two groups, the hard-billed and the soft-billed species, the former of which are supposed to feed on seeds while the latter subsist upon fruit and insects. From the standpoint of this classification the linnet would appear to be most emphatically a seed eater, and examination of the contents of stomachs of the species confirms the correctness of this view. Seeds of plants, mostly those of noxious weeds, constitute about seven-eighths of its food for the year, and in some months amount to much more. In view of this fact it seems strange that the house finch has acquired such a reputation for fruit eating, and it can be explained only upon the principle already laid down that in the fruit districts the bird is too numerous for the best economic interests. While each house finch eats but a small modicum of fruit, the aggregate of all that is eaten or destroyed by the species is something tremendous.

Moreover, it must be noted that not all of the fruit destroyed is eaten. Only one peck from the strong bill is necessary to break the skin of the pear, peach, or cherry, and the fruit is spoiled; the linnet by no means invariably visits the same individual fruit a second time to finish it, but often attacks a fresh one at each meal. This is proved by the large number of half-eaten fruits, either on the tree or on the ground beneath.

In large orchards, however, complaints against the linnet are fewer than formerly. Here the damage is more widely distributed and consequently less noticeable than when confined to a few trees. It is probable that the area of orcharding has increased more rapidly than the linnets, so that the proportional injury is less. At present the chief complainants are the owners of small town lots, where a few trees are grown to supply fruit for home use. As linnets are usually more numerous in villages and suburbs than in the country, trees in gardens are often entirely stripped.

INJURY TO FRUIT BUDS.

It is a little singular that formerly most of the complaints against the linnet were that it destroyed the buds and blooms of fruit trees instead of the fruit itself. Thus in 1886 Mr. R. P. Chandler, of Riverside, San Bernardino County, wrote:

> The bird which is commonly known as the linnet, or crimson house finch, has been observed to do great injury to the apricot crops of this section by feeding on the fruit buds from the time they begin to swell until the trees are in bloom. Two years ago my entire apricot crop was destroyed by the above birds, and I took the opportunity to establish the facts of the case by shooting a large number for the purpose of examination. A great many of the birds that were shot had small bits of buds, etc., stuck on their bills by the gummy substances of the fruit buds. A further examination would invariably result in finding each and every bird's stomach filled with buds.

The same year J. C. Galloway, of Tustin, Cal., stated:

> The common linnet does great injury to the buds of the apricot, eating out the center and destroying all the fruit buds on the tree in many cases, usually in January and February, in this latitude.

William Proud, of Rancho Chico, Cal., accuses the linnet of eating both buds and fruit. He says:

> The burion, house finch, or linnet, is by far the most pernicious bird we have to deal with in the orchard. He arrives in March and immediately commences his ravages on the buds of the cherry, peach, plum, persimmon, etc. The first cherry showing a red cheek is sampled by this most rapacious little bird. Then comes the fruit of the apricot, peach, and fig. For the latter he shows a decided partiality. When the fruit crop is exhausted he immediately turns his attention to all kinds of millets, sorghum, Egyptian corn, and other small seeds.

As showing how destructive the bird is to fruit, especially in small orchards, the following is quoted from Dr. T. S. Palmer, then at Berkeley, Alameda County, Cal.:

> The crimson house finch is the only bird that does any considerable damage to fruit. As soon as the cherries begin to ripen the birds keep close watch of the trees, and if the fruit is not gathered as soon as ripe they soon dispose of a large portion of it. In our garden there are about a dozen cherry trees of various kinds, and if not very closely watched, within a week or two from the time when the fruit first begins to ripen almost every tree will be completely stripped. Of course, in a large orchard the damage would not be so noticeable, but still might be considerable. Later in the season when the cherries are gone, the finches attack the plums and pears.

F. H. Holmes, of Rio Vista, Solano County, Cal., under date of September, 1886, states:

> Our worst fruit pest is the crimson house finch, which, on account of its abundance and familiarity, it is impossible to scare off. They injure mostly cherries, figs, berries, peaches, and apricots. They often only peck each fruit

a little, and then the bees and wasps take hold and finish the work. * * * Birds that destroy the earlier fruits are generally regarded as the greater nuisance, particularly to the farmer who has not a very extensive orchard. Where fruit is handled as soon as it is in the proper condition, or for an orchard of from ten to one hundred acres or more, I have never seen these birds plentiful enough to do a great amount of damage. In some parts of the State I presume they might do more.

In regard to the habit of the linnet of eating ripe fruit, Dr. A. K. Fisher says:

> In this valley [Owens], both at Independence and Lone Pine, the species [the linnet] was found to be very destructive to the ripened peaches during the middle of August. Flocks of birds occurred in the orchards, and in some places hardly an example of the ripe fruit could be found which was not more or less mutilated. A number of birds shot in the peach orchards at Lone Pine had little except the pulp of this fruit in their gullets or stomachs. It was known as the 'peach bird.'[a]

Examination of linnet stomachs does not reveal any very considerable number of blossom buds, and it is probable that but little of the alleged mischief to fruit blossoms is done by this bird. Moreover, it may be stated that in most cases budding by birds does little, if any, damage. It is only in very rare instances that birds take all the buds from a tree, or even enough to cause considerable loss. On the contrary, buds are usually superabundant, and budding, whether by birds or by man, is frequently beneficial, relieving the trees from excessive bearing and markedly improving both size and quality of fruit.

THE LINNET NATURALLY A SEED EATER.

Before the settlement of the Pacific coast region it is evident that the linnet must have subsisted almost entirely upon the seeds of plants growing wild in the valleys and canyons. With the advent of civilization two new articles of food were presented—grain and fruit. It would seem natural for the linnet, especially equipped as the bird is to extract the kernel of seeds, to have chosen the former, as did the blackbirds, doves, and some other species; but for some reason best known to itself it selected fruit. How much the character of the food had to do with the bird's choice it is impossible to say, but it is probable that attendant conditions greatly influenced the result. Grain is grown on large, open areas, with few or no trees to afford nesting sites, while orchards offer every inducement to linnets as a permanent residence. Moreover, much of the fruit-growing section of the State is divided into small holdings, each with a dwelling with accompanying barns, sheds, and other buildings that afford ideal homes for these birds. Having thus chosen the orchard

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[a] North American Fauna No. 7, U. S. Dept. of Agric., p. 80, 1893.

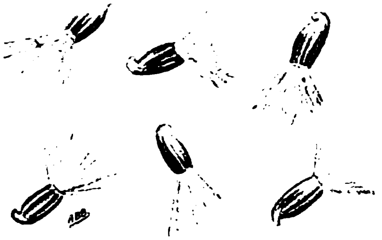

Fig. 1.

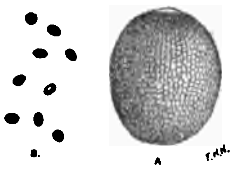

Fig. 2.

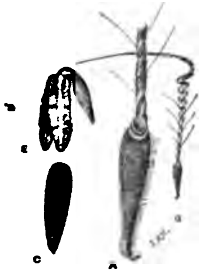

Fig. 3.

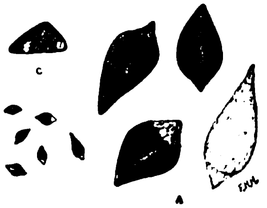

Fig. 4.

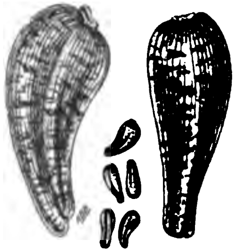

Fig. 5.

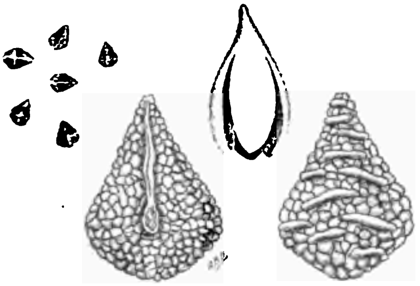

Fig. 6.

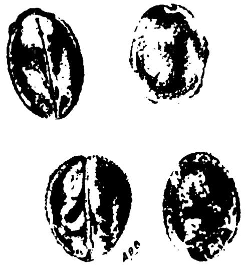

Fig. 7.

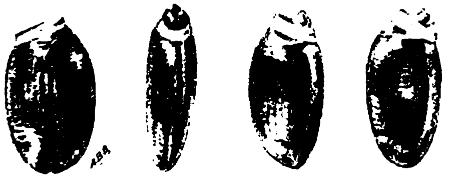

Fig. 8.

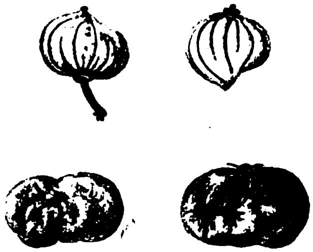

Fig. 9.

SEEDS OF COMMON WEEDS EATEN BY THE LINNET.

Fig. 1.—Napa thistle (*Centaurea melitensis*). Fig. 2.—Black mustard (*Brassica nigra*). Fig. 3.—Alfilaria (*Erodium cicutarium*). Fig. 4.—Knotweed (*Polygonum aviculare*). Fig. 5.—Tarweed (*Madia sativa*). Fig. 6.—Burweed (*Amsinckia tesselata*). Fig. 7.—Turkey mullen (*Eremocarpus setigerus*). Fig. 8.—Milk thistle (*Mariana mariniana*). Fig. 9.—Poison oak (*Rhus diversiloba*).

for its home it was only a matter of course that the bird should select as its secondary food the nearest available source of supply, namely, fruit. For seeds, which are to be regarded as the linnet's natural food, grow about the borders of orchards and by roadsides, and hence are readily obtained.

Although the great bulk of fringilline birds normally subsist principally upon seeds, at certain times, notably in the breeding season, they eat a considerable quantity of animal food, mostly insects. Moreover, their young while still in the nest are usually fed largely, and in some cases entirely, upon insects. Quite the contrary is true of the linnet. The adults eat only a small percentage of animal food, even in the breeding period, and feed their nestlings no more, perhaps less, than they eat themselves. In this respect the linnet is probably unique in its family. Such animal food as the bird does eat, however, is much to its credit. Plant-lice (Aphidæ), especially the woolly species, constitute a large portion of this part of the linnet's food; caterpillars and a few beetles make up most of the remainder.

It is, however, as a seed eater that the linnet stands supreme. Over 86 percent of its food for the year consists of weed seeds, and it is in this field, if anywhere, that the bird redeems itself from the odium of its other misdemeanors. When the immense number of linnets in California is taken into consideration, with the added fact that each one destroys several hundred seeds daily, most of which are potential weeds, it must be conceded that the bird renders a valuable service to agriculture, for the sum total of weeds so destroyed is enormous.

FOOD.

In the laboratory investigation of the food of the linnet 1,206 stomachs were examined, including 46 of nestlings. All were from California, and from points fairly well distributed over the State, with the exception of the northern quarter. The greater number were from the fruit-growing sections, so that the western coast region is better represented than the part east of the Coast Ranges. They were distributed through the year as follows:

January	88	August	118
February	35	September	123
March	186	October	108
April	80	November	25
May	74	December	54
June	167		
July	148	Total	1,206

In the first analysis of the food components the two principal elements are found to be: Animal matter, 2.4[a] percent; vegetable matter, 97.6 percent.

Animal food.—This brings into strong relief the linnet's sins of omission. Living in a country where constant war against noxious insects is necessary, the bird takes little or no part in the contest, and in return for benefits derived from man renders but slight service in this direction.

The small portion of animal food it takes, however, consists almost wholly of insects and a large proportion of it of plant-lice (Aphididæ), which from their small size do not attract the notice of many species of birds. They appear, however, to be the favorite animal food of the linnet, and it is noticeable that a large percentage of them are the woolly species. Many of the birds when killed had their beaks smeared with the remains of woolly aphides. As these insects are notoriously harmful to many trees and other plants, any bird that destroys them is a benefactor. It is to be regretted that the linnet should not indulge to a greater extent a taste so well directed. Were 25 percent of its food made up of woolly aphides the fruit it destroys would be well paid for. The other contingent of animal matter found in the linnet's stomach consists of small caterpillars and a few beetles, chiefly weevils. Most birds that feed on plant-lice eat also the ants that are usually in attendance upon them, but the only trace of ants or of other Hymenoptera in the stomachs of linnets was one ant's jaw. Grasshoppers, the favorite food of so many birds, were represented by a mere fragment in one stomach.

Vegetable food.—The most interesting part of the food of the linnet is the vegetable portion. This naturally falls into three categories: Weed seed, which amounts to 86.2 percent of the annual food; fruit, 10.5 percent; and other miscellaneous vegetable matter, 0.9 percent.

Fruit.—Fruit is represented in stomachs taken in January by a mere trace. This was probably of no value, only ungathered fruit or perhaps belated olives. In stomachs taken in February no fruit was found, but in ensuing months it appears in small quantities, increasing irregularly until August, when a maximum of 27.4 percent was eaten. In September a trifle less was taken than in August, and after that the quantity decreases until December, in which month a little less than 2 percent was eaten. In March the fruit amounted to about 6 percent, a quantity hard to account for except on the supposition that it was waste fruit left over from the previous year. The amount eaten in this month is somewhat surprising in view of the fact that in April less than 2 percent was consumed, and it is not until June that the percentage becomes important. It is possible that the supply of weed seed of the previous year may be exhausted by March, when the new crop has not yet ripened; so waste fruit is taken for want of something better.

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[a] While percentages are sometimes given in fraction, it need not be assumed that extreme accuracy is intended; such figures must be taken as only an approximation to the truth.

It is practically impossible to identify particular kinds of fruit in a bird's stomach unless characteristic seeds or stones are present. These are rarely eaten by the linnet, which seems to prefer orchard fruit. Cherries, apricots, peaches, and prunes appear to be the favorites. This choice arises, no doubt, from the character of its beak already described. While thrushes and other 'soft billed' birds prefer the smaller kinds commonly known as berries, which can be swallowed whole, the linnet attacks the larger kinds, which yield readily to its powerful beak. Linnets are particularly fond of small pears, like the Seckel, and often attack them even when they are hard, a fortnight or more before ripe. If undisturbed they will eat every one on a tree, leaving the core attached to dry and blacken in the sun.

A few strawberries and fewer blackberries or raspberries were the only cultivated small fruits that could be identified in the stomachs of linnets. A number of birds from the southern part of the State had fed freely on figs, identified by their seeds.

If the bird preferred an exclusive diet of fruit, there is no reason why its taste should not be gratified during the greater part of the year. When cherries are ripe in California linnets need eat nothing else. The cherry crop would be ample for all their wants, though perhaps not much would be left for marketing. The record, however, shows that in June, which is practically cherry month in the central part of the State, less than one-seventh of the linnet's food consists of fruit. Apricots are ripe in many parts of the State before the month closes, so that lack of fruit can not be urged as a reason why the bird should subsist so largely upon weed seed. In July apricots, peaches, and early figs are available, but still the linnet eats them only to the extent of one-fifth of its diet, and even in August and September, the months of maximum consumption, fruit constitutes only a little more than one-fourth of the food.

Weed seeds.—The greater portion of the linnet's food, as already stated, consists of the seeds of weeds, the most important of which are those of the Napa thistle, black mustard, Alfilaria, knotweed, and turkey mullen (see Pl. II, figs. 1, 2, 3, 4, 7), the total consumption of which for the year is 86.2 percent. This record is not excelled by that of any other bird studied, with the possible exception of the tree sparrow (*Spizella monticola*), whose food, however, consists largely of grass seed, much of which is useful. As there is an unaccountable increase in the fruit eaten in March, so there is an unexplained decrease in the consumption of weed seed during that month. With that exception, the amount taken in each month decreases in a fairly regular series from a maximum of 99.8 percent in January to a minimum of 64 in August. From this month the quantity of seed in the stomachs increases steadily to December, when the record ends with 97.9 percent.

It seems probable that such a constant and persistent eater of weed seed would also eat considerable grain. Stomach records show that wheat was identified in one stomach, oats in three, and something very like the skin from kernels of corn in five. In this connection it can be said that if the linnet does not eat grain it certainly is not for want of opportunity. It is evident then that weed seed is taken by the linnet simply because it likes it.

SUMMARY.

It is natural to conclude that the food most frequently found in a bird's stomach is the kind preferred. Applying this test to the linnet we find that of the total 1,206 stomachs examined, 1,133, or 94 percent of all, held weed seed, and that 807, or nearly 67 percent of the whole, contained no other food. On the other hand, fruit was found in 297 stomachs, or 24 percent of the whole number, but only 38, or 3 percent of all, were entirely filled with it. In other words, there were only 63 stomachs that did not contain weed seed, while 909 contained no fruit.

The miscellaneous portions of the linnet's vegetable food amount to only about nine-tenths of 1 percent of the food of the year, and all was found in 28 stomachs. Stamens and other parts of flowers were found in 14 stomachs only, which does not indicate that the injury to fruit buds by the linnet is serious. One stomach contained a small leaf gall. Ten stomachs held matter denominated as rubbish, consisting of bits of dead leaves, rotten wood, etc., evidently swallowed unintentionally with other food.

From the foregoing it appears that, contrary to the statements and beliefs of many, the linnet is not a constant and persistent devourer of fruit. Examination of the contents of many stomachs shows that fruit is far from being its principal article of diet, and it is probable that what is taken is eaten for the sake of variety or for the juice. A far greater quantity of fruit is eaten by the cherry bird (*Ampelis cedrorum*) and by the robin (*Merula migratoria*), both of which occur in California.

PROTECTION OF FRUIT FROM LINNETS.

In the case of both these birds, however, the greater part of the fruit eaten consists of wild species, and this fact suggests a method by which the California fruit grower may protect his orchards from the attack of the linnet—namely, by planting around orchards shrubs and trees the fruit of which will serve to attract birds away from the marketable kinds. There are many fruit-bearing shrubs and trees whose products, while worthless to man, are likely to prove more attractive to linnets than are the orchard fruits. That linnets will eat wild fruit appears from the fact that elderberries (Sambucus) were found in 49 stomachs, and their apparent partiality for cultivated fruits is readily explained by the fact that usually they are the only kinds obtainable.

FOOD OF YOUNG LINNETS.

Of the 1,206 stomachs of linnets included in this investigation, 46 were those of young birds taken from the nest. The young vary in age from birds 2 days old to those nearly ready to fly. In order to ascertain the exact difference, if any, between the food of the nestlings and that of the adults, the contents of these 46 stomachs were tabulated by themselves and the percentages of the various items of food calculated. The results show 2.4 percent of animal food to 97.6 of vegetable. The animal food consists mostly of the larvæ of a minute beetle which lives on decayed fruit, with a few plant-lice and one small fragment of a grasshopper, the only one found in any of the stomachs. The vegetable food consists entirely of weed seed, the most important of which are the following: Sunflower, bur weed, milk thistle, and poison oak. (See Pl. II, figs. 6, 8, 9.)

No fact connected with the food habits of the linnet is more surprising than this. The great body of the fringilline birds, though subsisting largely and in most cases almost entirely upon vegetable food in adult life, feed their young in the early stage of existence almost exclusively upon insects or other animal food, and begin to give them vegetable food only when nearly ready to leave the nest. It is doubtful if there is an exception to this rule so pronounced as the linnet. As calculated, the nestlings ate actually less animal food than their parents, but the difference is so small that it may be accidental.

ECONOMIC PLACE OF THE LINNET.

Admitting, as we must, that the orchardist has just grounds of complaint against the linnet on account of depredations upon fruit, the bird's claim to favorable consideration must rest upon its valuable services as a consumer of weed seed and upon its esthetic value. It is trim and pretty, has a sweet song, and in many ways is a pleasing adjunct of rural life—in fact, many Californians believe that the linnet, in spite of its sins of commission and omission, should be protected. That the complete extermination of the species, even if possible, is not desirable will be readily allowed, but that a reduction of its present numbers would be for the general welfare can not reasonably be denied. Were it possible to destroy half the linnets in the fruit-growing sections of the State, there is no doubt that most of the complaints against the species would cease. As it is, the fruit grower must protect himself by such devices as are suggested by local conditions, and bear in mind that, while as an individual he may suffer, the bird, on the whole, is doing the State good service.

LIST OF SEEDS FOUND IN STOMACHS OF LINNETS.

Following is a list of identified seeds, with the number of stomachs in which each kind was found. The same kinds of seeds were of course contained in many more stomachs, but were so finely ground up as to be unidentifiable. It is not unlikely that in identifying the seeds specifically errors have been made, but it is believed that few, if any, of the generic identifications are erroneous. A few seeds were found which have not yet been identified.

Sedge (*Carex* sp.)	21
Sorrel (*Rumex acetosella*)	3
Knotweed (*Polygonum aviculare*). (Pl. II, fig. 4)	128
Catchfly (*Silene* sp.)	51
Chickweed (*Stellaria media*)	21
Spurry (*Spergula arvensis*)	14
Amaranth (*Amarantus retroflexus* et al.)	108
Calandrinia (*Calandrinia menziesi*)	2
Miner's lettuce (*Montia perfoliata*)	11
Wild turnip (*Brassica campestris*)	13
Black mustard (*Brassica nigra*). (Pl. II, fig. 2)	83
Wild radish (*Raphanus sativus*)	108
Geranium (*Geranium dissectum*)	3
Alfilaria (*Erodium moschatum*)	392
Alfilaria (*Erodium cicutarium*). (Pl. II, fig. 3)	
Yellow sorrel (*Oxalis corniculata*)	1
Turkey mullen (*Eremocarpus setigerus*). (Pl. II, fig. 7)	117
Poison oak (*Rhus diversiloba*). (Pl. II, fig. 9)	1
Burweed (*Amsinckia tesselata*). (Pl. II, fig. 6)	3
Nightshade (*Solanum nigrum*)	4
Western ragweed (*Ambrosia psilostachya*)	3
Sunflower (*Helianthus* sp.)	5
Mayweed (*Anthemis cotula*)	1
Groundsel (*Senecio vulgaris*)	21
Lesser tarweed (*Deinandra fasciculata*)	1
Tarweed (*Madia sativa*). (Pl. II, fig. 5)	5
Milk thistle (*Mariana mariniana*). (Pl. II, fig. 8)	3
Napa thistle (*Centaurea melitensis*). (Pl. II, fig. 1)	60

The following table shows the percentages of the various items of food of the linnet for each month of the year:

Table of percentage of food of the linnet for each month in year.

Month.	Number of stomachs examined.	Animal food eaten.	Vegetable food eaten.			
			Weed seed.	Fruit.	Miscellaneous.	Total vegetable food.
		Percent.	*Percent.*	*Percent.*	*Percent.*	*Percent.*
January	88	0.0	99.8	0.2	0.0	100.0
February	35	2.9	97.1	0.0	0.0	97.1
March	186	1.0	89.5	5.8	3.6	99.0
April	80	5.8	92.5	1.7	0.0	94.2
May	74	6.3	88.9	4.8	0.0	93.7
June	167	3.9	81.6	13.4	1.2	96.1
July	148	2.2	76.5	19.7	1.5	97.8
August	118	7.1	64.0	27.4	1.5	92.9
September	123	0.1	71.6	26.7	1.6	99.9
October	108	0.0	83.5	15.6	0.9	100.0
November	25	0.0	91.7	8.3	0.0	100.0
December	54	0.0	97.8	1.8	0.4	100.0
Total	1,206					
Average		2.4	86.2	10.4	0.9	97.5

WESTERN TANAGER.

(*Piranga ludoviciana.*)

The western tanager, like the robin, occasionally becomes a nuisance in the orchard. It breeds in the mountainous regions of California and northward, and as a rule is not common in the fruit-growing sections.

DAMAGE TO CHERRY CROP.

There are, however, times during migration when it fairly swarms in some of the fruit-raising regions, and unfortunately this sometimes happens just at the time when the cherry crop is ripening. The bird is a late breeder and does not seem to care to get to its nesting ground before the last of June or early July. It is thus enabled to begin in the southern part of the State when cherries are ripening there, and leisurely follow the ripening fruit northward. The year 1896 witnessed an incursion of these tanagers, when they swarmed over much of the State and destroyed a large part of the cherry crop.

Probably the best account of this occurrence is that of W. O. Emerson (published in the Condor, Vol. V, 1903, p. 64). Mr. Emerson says:

> One of the most wonderful occurrences of the movements of birds in the season of migration which ever came under my notice, took place at Hayward during May, 1896, when countless numbers of *Piranga ludoviciana*, or Louisiana tanagers, began to make their appearance between May 12 and 14. From the 18th to the 22d they were to be seen in endless numbers, moving off through the hills and canyons to their summer breeding range in the mountains. This continued till the 28th, and by June 1 only here and there a straggling member of

the flock was to be seen. They were first found feeding on early cherries, in an orchard situated along the steep bank of a creek, on the edge of rolling hills, well covered with a thick growth of live oaks, which faced the orchard on the east. To this thick cover they would fly, after filling themselves with cherries, and rest till it was time to eat again. This they would keep up from daylight to dark, coming and going singly all day, without any noise whatever being heard.

Two men were kept busy shooting them as fast as they came into the trees which lay on the side next to the oak-covered hills. * * * After the first week, I found on going here (May 17), that dozens on dozens of the birds were lying about. * * * Tanagers lay about everywhere, and no doubt many must have flown off to die in the bushes or on the hillsides. * * * I noticed one fact of the restriction of the tanagers to the orchards along the hill edges. None were found, so to speak, in the larger orchards about the town of Hayward. * * * Mr. H. A. Gaylord, of Pasadena, Cal., in a letter under date of June 16, 1896, states that "they were seen singly from April 23 to May 1. From this date up to May 5 their numbers were greatly increased, and by May 5 there was an unusually large number of them. Then for about ten days, until May 16, the great wave of migration was at its height. Tanagers were seen everywhere, and noticed by everyone. After May 20 they decreased in numbers, and by May 26 the last ones had left the valley." * * * He also says: "The damage done to cherries in one orchard was so great that the sales of the fruit which was left, did not balance the bills for poison and ammunition. The tanagers lay all over the orchard, and were, so to speak, 'corded up' by hundreds under the trees."

There must have been thousands of tanagers destroyed all through the path of their movement along the State, as they worked their way to the breeding grounds.

Here are two accounts of this great flight of tanagers—one from Pasadena, the other from Hayward, 330 miles farther north as the bird flies. The time taken by the tanagers in traversing this distance was only eight days, so it would appear that individual birds did not spend much time in the same orchard. Such sporadic flights are hard to account for. The tanagers are in California every year, and every year they migrate to their nesting grounds in spring and return in fall, but only at long intervals do they swarm in such prodigious numbers. Evidently the migration ordinarily takes place along the mountains where the birds are not noticed. It is possible that in some years the mountain region lacks the requisite food, and so the migrating birds are obliged to descend into the valleys. This would seem to be the most plausible explanation of the occurrence—that is, that the usual line of migration is along the Sierra Nevada, but some years, owing to scarcity of food, or other cause, the flight is forced farther west into the Coast Ranges, where the birds find the ripening cherries. The damage done by this species, however, is not confined exclusively to the rare occasions when they appear in such extraordinary numbers. R. H. Carr, of Redlands, southern California, wrote us in June, 1899:

Without examining any stomachs it is easy to report the value of the Louisiana tanager to the fruit growers near here. In the city they seem to keep almost entirely on the Grevillea trees, sipping the sweet liquid that exudes from the blossoms. But the Andrews Brothers, whose cherry and apple ranch is in the upper Yucaipe Valley, report that the tanagers destroyed about $4,000 worth of cherries, being almost the entire crop. They used powder and shot liberally, but did not save the crop.

It is to be regretted that some of the stomachs of these tanagers were not saved, in order that the diet of the species might be ascertained with precision. The only material available for examination consists of 46 stomachs from various parts of the State, during the six months from April to September, inclusive. This number is entirely too small to afford positive data as to the regular food habits of the bird, but undoubtedly points in the right direction. Although the testimony of field observers shows that this tanager eats a good deal of fruit, analysis of the stomach contents proves that over 82 percent of the food for the six months indicated above consists of insects, and the remainder, nearly 18 percent, of fruit, with a mere trace of seeds of a conifer.

Insect food.—The largest item of the animal food is Hymenoptera, most of which are wasps, with some ants. Altogether they amount to 56 percent of the food for the six months, and in August they reach 75 percent. (They reach 92 percent in April, but only one stomach was taken in that month, so the record is not reliable.) Hemiptera stand next in importance, with 8 percent. They are mostly stink-bugs, with a few cicadas. Beetles amount to 12 percent of the food, of which less than 1 percent are useful Carabidæ. The remainder are mostly click-beetles (Elateridæ) and the metallic wood-borers (Buprestidæ), two very harmful families. The former in the larval stage are commonly known as wireworms, and bore into and destroy or badly injure many plants. The Buprestids, while in the larval stage, are wood-borers of the worst description. Grasshoppers were eaten to the amount of 4 percent, and caterpillars to the extent of less than 2 percent.

Fruit.—The greater part of the fruit eaten appeared to be the pulp of some large kind like peaches or apricots. One stomach contained seeds of elderberries; another the seeds and stems of mulberries, and two the seeds of raspberries or blackberries. Nearly all these stomachs were collected in the mountains, away from extensive orchards, but still the birds had obtained some fruit, probably cultivated.

SUMMARY.

It is evident from the testimony that great damage from this species occurs only at rare intervals and during the spring migration. The greatest losses occurred in May, 1896, when the damage to the cherry crop in certain localities was most disastrous. As, under ordinary circumstances, the greater part of the food of this bird consists of insects, many of them harmful, the tanager has a fair claim to consideration at the hands of the farmer and even of the orchardist.

It is probable that means may be found to prevent, at least in part, the occasional ravages of the tanager on the cherry crop. The tanager, like the robin, prefers to swallow fruit whole, and as the latter takes small wild cherries in preference to the larger, cultivated kinds when both are equally accessible, it is probable that the tanager would do the same; and it is suggested that a number of wild cherry trees planted around California orchards might prove an economical investment for the orchardist.

SWALLOWS.

Swallows are the light cavalry of the avian army—always on the move, always on the skirmish line, ever gathering stragglers from the insect camps. They furnish another instance, and perhaps the most remarkable one, of change of habit induced by civilization. In eastern United States the bank swallow and the rough-wing are the only species that adhere persistently to their original nesting sites. In the West a third species may be added to these, the violet-green swallow; but there all the swallows are somewhat less domestic than in the East. It is probable, also, that some species, notably the barn swallow, are more abundant than when the country was unsettled, owing to the increased number of nesting sites. Supposing for a moment that the country was swept bare of buildings, where could all the barn swallows find suitable places to nest? The cliff swallows might discover enough overhanging cliffs upon which to attach their mud domiciles; the white-bellied and the martin, as formerly, might nest in the hollows of trees, but there are not caves enough east of the Mississippi River to afford nesting places for one-tenth of the barn swallows. In the far West they would fare better. When the country was first settled, barn swallows must have been confined to a few rocky cliffs and caves here and there along the seashore or in mountains. Now they live wherever man has erected a structure of any kind.

As is to be inferred from the movements of these birds, their food, with some curious exceptions, consists principally of insects caught in mid-air. For this reason all the species are migratory, except in the Tropics, for the food supply fails in regions where frosts prevail. As many insects that usually do not fly, periodically 'swarm,' they are often captured by swallows at such times in great numbers. Such is the case with ants and 'white ants' (Termitidæ), which most of the time are concealed in the earth or in logs, but at certain times 'swarm' in immense numbers. Many species of beetles that live in offal and ordinarily are not accessible to birds, in case of failure of food, migrate in great numbers, and then are preyed upon by swallows, flycatchers, and other birds. The destructive cotton boll weevil is more or less active during the late summer and early fall months, and it has been learned that the swallows, as they pass through the cotton States on their way to their southern winter quarters, catch great numbers of them on the wing and so perform an exceedingly important service. Engraver beetles (Scolytidæ) have frequently been found in the stomachs of swallows. These insects live under bark, and generally are inaccessible to birds, except woodpeckers; periodically they migrate from the tree where hatched and matured to search for fresh pastures; at such times they are unprotected and fall easy prey to any fly-catching bird. Swallows are peculiarly adapted to capturing small insects in mid-air. While their bills are weak their mouths are wide, and their long wings enable them to fly swiftly and turn quickly, so that they sweep back and forth through a swarm of insects and gather them by hundreds.

Seven species of swallows, with several subspecies, are commonly found within the limits of the United States. Their food habits vary but little. All seven species occur in California, and this number includes one, the violet-green, that does not occur in the East.

Besides the swallows whose food will be discussed in detail in the following pages, a few stomachs of the tree swallow (*Iridoprocne bicolor*), the western martin (*Progne subis hesperia*), and the bank swallow (*Riparia riparia*) have been examined, but the number is entirely too small to be used as a basis for general conclusions were it not for the fact that their contents agree in all essential points with those of the other swallows, of which a greater number were available for examination. In fact, it may be said of all the members of the swallow family that they subsist upon practically the same kind of food, with slight variation from month to month. It may be laid down as a general rule that the food of all American swallows is derived from the following orders of insects: Coleoptera, Hymenoptera, Hemiptera, and Diptera, with a few individuals from one or two other orders, and an occasional spider. So far as present investigation has shown, 90 percent of their animal food is from the four orders named above, but the relative proportion of each varies somewhat with the different species and seasons. With one notable exception[a] the swallows take so little vegetable food that it may be passed by as a negligible quantity, and much even of the little eaten is probably swallowed accidentally.

After the above statements in relation to the food of the swallows, it is perhaps unnecessary to dwell upon the great value of these birds as insect destroyers. They do not consume any product of husbandry, and the worst that can be said of them is that they eat some useful insects with the harmful ones, though the former are in a very decided minority. This statement, however, applies to any and all insect-eating birds. It would be just as reasonable to expect a mower or reaper to cut grain and leave the weeds standing as to suppose that from the hordes of insects around us birds will select only the ones that are injurious to man and leave untouched those that are beneficial. Then, too, a superabundance of any species of insects, even beneficial ones, would be a nuisance. The service which swallows render is to prey upon the whole insect tribe and so to reduce the flood of insect life to a lower level where it may be more easily dealt with by man.

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[a] The tree swallow of the East (*Iridoprocne bicolor*) during its southern migration freely eats the berries of the bay-berry (*Myrica carolinensis*).

CLIFF SWALLOW.

(*Petrochelidon lunifrons.*)

In the Eastern States the cliff swallow has practically abandoned its original nesting sites under cliffs, and now nests under the eaves of houses and other buildings. The writer has counted 80 nests beneath the eaves of 1 barn. In California the bird has taken up with the new order of things to some extent, but has not entirely abandoned its old habits. It is a migrant and remains in the State for about six months only during the breeding season, which is the time when the bird does the most good.

The following discussion of the food of the cliff swallow is based upon the examination of 123 stomachs, representing every month from April to September, inclusive.

Vegetable food.—Vegetable food to the extent of 0.32 of 1 percent was found. In most cases this was simply rubbish taken accidentally, though it includes a few small seeds.

Animal food.—Of the animal matter the largest item is Hymenoptera. These insects formed over 39 percent of the total food; most of them were bees and wasps, and small parasitic species were identified in a number of stomachs; a few were ants. Unfortunately, many parasitic insects are eaten by birds that take their prey upon the wing, such as swallows and flycatchers. The fact is to be deplored, but in most cases the percentage is not large. Perhaps the most interesting insect among Hymenoptera eaten is the common honey-bee (*Apis mellifera*). Of these, 34 were identified, all contained in 11 stomachs, in one of which were 8 individuals. All were drones—that is, males. Not a trace of a worker bee was found. In two stomachs drones constituted the whole food and in several others the principal part. It is probable that most of them were taken when the queen made her marriage flight. So far as the writer has been informed, bee keepers do not regard the destruction of drones as injurious to the swarm. In most cases drones are superabundant and instead of contributing to the food supply they are a drain upon it, so that the destruction of some of the surplus males is a positive benefit to the colony.

Hemiptera, or bugs, stand next to Hymenoptera in importance in the food of the cliff swallow. They form a little less than 27 percent of the whole diet, and are represented by eight families, namely, assassin-bugs, leaf-bugs, squash-bug family, stink-bugs, shield-bugs, tree-hoppers, leaf-hoppers, and jumping plant-lice.[a] All of these, excepting the assassin-bugs, are injurious to plants, and some of them are pests at all times. Of these, probably the leaf-hoppers (Jassidæ) are the worst. They suck the juices of plants, particularly grasses, which they infest by millions. They are said to have but few enemies, of which birds are the most effective. It is probable that they are captured by swallows when just skimming over the surface of fields, or are snatched from the tops of grass and weeds. They were found in 27 stomachs.

Leaf-bugs (Capsidæ) are a very large family of harmful insects, which feed almost entirely upon plants. Some species of this family are pests of the worst description. Leaf-bugs were contained in 43 stomachs. The other insects of this order are more or less harmful, but were not eaten so extensively.

Beetles of all kinds aggregate a little less than 19 percent. Of these, 2 percent were useful species, such as carabids and coccinellids. The others belong to 12 different families, most of which are harmful, some very much so. Among them were a number of aquatic species. These were probably captured by the swallows when flying just above the surface of the water. The principal flights of beetles do not occur during the day, but chiefly in early evening and at night.

Flies are eaten by cliff swallows to the extent of nearly 12 percent of the food. Most of these are the species commonly known as gnats, but one stomach contained a large horsefly (Tabanidæ). The gnats have a habit of swarming afternoons and evenings, when many are probably snapped up by swallows.

The remains of dragon-flies, lace-winged flies, ephemerids, and spiders make up the rest of the food, or a little more than 3 percent. As spiders do not fly, it may be asked how they were captured by the swallows. They probably were snatched from their webs or from the tops of weeds as the birds passed. Swallows pick up substances even from the ground, as is shown by the vegetable component of their food, and by other facts to be given presently.

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[a] Plant-lice and scale-insects were not present, and this may be explained from the fact that their lives are passed mostly in a wingless condition.

FOOD OF YOUNG.

Among the stomachs examined were those of 22 nestlings, varying in age from 2 days to those just ready to leave the nest. They were taken from May 30 to July 2, inclusive. In order to ascertain if important differences exist between the food of the adults and that of the young, the contents of these stomachs were tabulated separately. Comparison shows little or no difference in the quantity of vegetable matter eaten by adults and young.

The animal matter in the food of the young is precisely of the same kind as eaten by adults, but the proportions are rather different. Hymenoptera are the largest item in the food of the young as well as of the parent birds, and amount to 42 percent for the former against 39 percent for the latter. Diptera stand next in importance, with 30 percent for the young against 12 percent for the adults. As these insects are mostly soft-bodied, it is the usual custom of birds to feed a greater proportion of them to the young. Hemiptera amount to a little more than 16 percent of the nestlings' food, while the adults eat them to the extent of nearly 27 percent. Beetles are fed to the young to the amount of about 10 percent, while the parents eat them to the extent of 19 percent. This again might naturally be expected, as most beetles are hard and less easily digested than flies and some other insects, and hence are less suitable food for young birds.

From the foregoing it is evident that the food of young cliff swallows does not differ in kind from that of the adults, but is distributed among the various orders of insects in somewhat different proportions. Hymenoptera and Diptera constitute nearly three-fourths of the diet, evidently because they are soft and easily broken up and digested. Beetles and bugs appear in the stomachs less frequently. While beetles are not extensively eaten, it is worthy of note that the variety is considerable, as representatives of no fewer than 10 species were contained in the stomach of one nestling. One stomach held a few bits of eggshell, and gravel was identified in two others. One of these contained 7 good sized gravel stones; the other, pieces of glass and gravel. The supposed function of gravel in the stomachs of birds is to assist in breaking up the food. That gravel should be given young cliff swallows when not taken by the adults is remarkable. The feeding of gravel to the young has been noted in the case of other species of swallows.

WESTERN BARN SWALLOW.

(Hirundo erythrogastra.)

The barn swallow is rapidly learning, not only that the structures built by man afford excellent nesting sites, but that the presence of man is a sufficient protection against enemies. This species is generally distributed over the west coast region, but it is not so common as it is in the East, probably because of the relative scarcity of nesting sites. It is not improbable, however, that the end of the present half century will see the barn swallow as common throughout the whole of the region as it is in the East.

Eighty-two stomachs of barn swallows were examined, taken from April to October, inclusive, though April was represented by only two stomachs and October by one. While a greater number would have been desirable, the close resemblance of the food to that of the eastern birds, as shown by the contents of these stomachs, gives assurance that the results are reasonably reliable.

Vegetable food.—Practically no vegetable food was found in the stomachs examined. A single unknown seed was contained in a stomach taken in September.

Insect food.—So far as these 82 stomachs show, the western barn swallow subsists entirely upon insects, and it may be added that the same is true of the eastern bird.

The largest item of food is made up of Hemiptera of various families, amounting to nearly 39 percent of the whole. None of these insects was present in the two stomachs taken in April, but in every other month they constitute a large percentage of the stomach contents, and in September, when 38 stomachs were taken, they amount to 90 percent of the food for that month. Representatives of 8 families were identified, but the principal and most important ones are the leaf-bugs (Capsidæ), which were found in 44 stomachs.

Flies are next in importance, and amount to 32 percent of the food. Most of them belong to the family of the common house fly (Muscidæ), though probably there were others too badly mangled to be identified. No long-legged crane-flies (Tipulidæ), usually commonly eaten by birds, were found.

Hymenoptera constitute 18 percent of the food. Most of them consist of wasps and wild bees, but a few stomachs contained ants. One stomach had a drone honey-bee. Several birds had eaten parasitic species of Hymenoptera; a separate account was kept of these so far as possible, but the total amount summed up to only about one-fourth of 1 percent of the whole food.

Beetles aggregate nearly 10 percent of the whole, and belong to 13 families, with no preference for any. The bird probably snatches any and all beetles which it comes across. A few of the destructive engraver beetles (Scolytidæ) were found in 3 stomachs. Dragonflies and several unidentified remains constitute the remainder of the food and amount to a little more than 1 percent.

FOOD OF YOUNG.

The stomachs of two broods of nestlings of 4 each are included in the foregoing. The contents do not differ from those of adults except that they include a small percentage of gravel. Some of them contained also fragments of eggshell; one had a piece of mother-of-pearl (nacre), and one a small splinter of bone. It is curious that these indigestible substances should be so often fed to nestlings when the parent birds seldom take them.

VIOLET-GREEN SWALLOW.

(*Tachycineta thalassina lepida.*)

The violet-green swallow does not occur east of the Great Plains. Its general habits appear to be almost identical with those of its eastern relative, the white-bellied swallow.

The natural nesting site of both species was a hollow in a tree, and the western bird still adheres to the original habit and nests in the hollows of oaks and other trees, but the white-belly has to a great extent followed the example of so many of its relatives, and has taken to holes in buildings or to boxes put up for avian use.

In its food habits the violet-green exhibits no marked peculiarities; in fact it may be said that the food of the different species of swallows differs in degree rather than in kind. Stomachs of the violet-green have been collected in every month, except June, from March to September, inclusive, but only 7 were taken earlier than July. In that month, however, and the two following months 67 were obtained, a sufficient number to give a fair idea of the food at this season.

Insect food.—Insects constituted practically the entire contents of these stomachs. No spiders were found, and the only vegetable matter was a single seed, no doubt accidental.

As with the barn swallow, the largest item is Hemiptera, or bugs. These are represented by 10 different families, of which the leaf-hoppers (Jassidæ) were the most numerous, and the leaf-bugs (Capsidæ) next. Altogether they amount to 36 percent of the food.

Diptera stand next in importance, and in this respect also the violet-green resembles the barn swallow. They constitute nearly 29 percent of the food. Neither Diptera nor Hemiptera, however, are eaten as freely by the violet-green as by the barn swallow, and the deficiency is made up by Hymenoptera.

Hymenoptera amount to 23 percent of the food, and in the month of July were mostly made up of ants. Six stomachs taken on the same day and in the same locality were entirely filled with these insects. One taken at the same place on the following day was half filled with them, and this, with the exception of 1 percent contained in one stomach in August, is the whole story of ants in the food of the violet-green. All of the other hymenopterous food consists of wasps and wild bees. In explanation of the fact that this bird eats ants freely for a short time and then eats no more, it may be stated that much of the time they are not obtainable. It is only when the insects are on the wing while swarming that the swallows can catch them, and then, being very numerous, they are eaten freely.

Beetles collectively amount to something over 11 percent of the food of the violet-green. Of these nearly 3 percent are Carabidæ, with a few coccinellids and carrion beetles, which must be reckoned as useful insects. The rest, over 8 percent, are of several families, all of which are more or less harmful. Three stomachs, collected at the same time in Carmel Valley, are of interest. They contained respectively 42, 45, and 40 percent of scolytid or engraver-beetles. This was in the region of the Monterey pine (*Pinus radiata*), and there is no doubt that these insects prey upon those trees, and probably were taken when migrating in a swarm to fresh foraging grounds. A few moths, with some unidentified insects, make up the remainder of the animal food, a little more than 1 percent.

CALIFORNIA SHRIKE.

(*Lanius ludovicianus gambeli.*)

The California shrike is common in parts of the Pacific coast region. At the present time fence posts and telegraph lines are the vantage points from which shrikes ordinarily scan the ground for prey, and in certain parts of the valley region it is unusual to glance along a line of wire and not see one or more within a short distance. It does not seem that trees and shrubs could ever have adequately supplied the need for lookout stations which is now filled by the poles and wires.

There seems to be a mysterious sympathy between the shrike and the little sparrow hawk, or perhaps their relations are inspired by jealousy. The sparrow hawk also occupies the poles and wires as a lookout for prey, and whenever a hawk stations himself upon one of the poles, there, at no great distance, is sure to be a shrike keeping close watch upon the movements of the larger bird. When the latter moves the shrike follows, and seems to aim to keep the other continually in view. Perhaps the shrike sees in the hawk a rival and considers that his preserves are being trespassed upon, though one would think there was room enough and prey enough for both. No case of actual conflict between the two has been observed—only this constant and unremitting surveillance on the part of the shrike.

The shrike resembles a bird of prey in form of beak and, to a certain extent, in food habits. Unlike the true birds of prey, however, its feet are not provided with talons for seizing prey and holding it securely while it is being torn into pieces. Whenever the shrike captures game that must be torn apart it presses it firmly down into a forked branch where it can readily be dissected.

The habit of the shrike of storing food apparently for future consumption has often been noticed. When food is abundant surplus captures are hung on thorns, sharp twigs, or, in recent times, the barbs of wire fences until needed; but as such occasions seldom arise, nine-tenths of this stored food is wasted so far as the shrike is concerned. Various more or less plausible explanations of this habit have been offered, but the simplest and most natural seems to be that much of the time the bird hunts simply for the pleasure and excitement of the chase, and as prey is often captured when hunger has already been satisfied it is stored for future use. It is the same instinct and lust for slaughter that prompts man to kill game that he can not use. The habit seems to be manifested also in a somewhat different way by the crow and magpie, which store up bits of glass or bright metal for which they can have no possible use. In the case of the shrike, however, the habit is useful to man if not to the bird, for most of its prey consists of noxious creatures, the destruction of which is a decided benefit.

The diet of the shrike and that of the sparrow hawk are almost exactly alike. It is a curious illustration of two species standing far apart systematically but by special modification approaching each other in food habits. The sparrow hawk has all the equipment of a carnivorous bird, but owing to its diminutive size its attacks are necessarily confined to the smaller kinds of prey, largely insects. The shrike, on the other hand, is a member of a group almost purely insectivorous, but it is so large and strong and has a beak so modified that in addition to its ordinary diet of insects, it is able on occasions to capture and tear apart small birds and mammals. While at present the two birds subsist upon much the same diet it is evident that their food habits have been modified in different ways. The natural food of the hawk family as a whole is vertebrate animals, to which some of its members, including our little sparrow hawk, have added a large percentage of insects. The normal food of the shrike is insects, to which on occasions it adds the smaller species of vertebrates.

Like the birds of prey and some other birds, the shrike habitually disgorges the indigestible portions of its food after the nutritive part has been digested. The bones and hair of mice are rolled into compact pellets in the stomach and finally disgorged. From examination of these a very good idea of the shrike's food may be gained.

A shrike of the eastern subspecies was kept in confinement for some weeks by the Biological Survey and notes made in regard to its food habits. A thorny bush was placed in the cage, and whenever the bird was given food in excess of its immediate wants it impaled the surplus upon a thorn, taking great pains to press it securely down. On one occasion a dead mouse was placed in the cage; it was at once seized and forced into the fork of the bush and was then torn piecemeal and eaten. Note was taken of the time when the last bit was swallowed, and a close watch kept for further results. In an hour and a half the bones and hair of the mouse were disgorged in the form of a neat pellet. Everything digestible had been stripped from the bones. A May-beetle (Lachnosterna) was eaten and the pellet containing the remains appeared in an hour and twenty minutes. At another time a ground beetle (Calosoma) and a stink bug (Nezara) were eaten and their remains appeared in forty minutes. As both of the insects are nauseous, at least to human smell and taste, it is possible that they may have been unacceptable to the stomach of the bird, and so were rejected before digestion was complete. On another occasion a second Calosoma and a moth were given, and their remains were regurgitated in an hour and fifteen minutes. These experiments show how rapid is the process of avian digestion.

In the investigation of the food of the California shrike 124 stomachs were examined. They were collected in every month, but the greater number were taken in the warmer months.

Vegetable food.—Animal food of all kinds amounts to 97.5 percent, or so nearly the whole that it is fair to suppose that the greater part of the 2.5 percent of vegetable matter present was swallowed unintentionally—that is, when sticking to something else. All of it was contained in 9 stomachs. Fruit appeared in 2 stomachs, seeds in 2, and rubbish in 6. Of these probably only the fruit was taken as food. One stomach was filled with elderberries to the amount of 84 percent of the contents, the other with the seeds of blackberries or raspberries to the extent of 13 percent. It thus appears that the shrike sometimes eats fruit.

Animal food.—The animal portion of the shrike's food may be divided into three parts: Insects, 83 percent; spiders and a few snails, etc., 2 percent; vertebrates, 12 percent.

Insect food.—In comparing the food of eastern subspecies of shrike and the one under discussion, we find that more insects are eaten by the western one. The figures for the eastern bird are: Insects, 68 percent; spiders, 4 percent; vertebrates, 28 percent. The difference is undoubtedly due to climate, the western bird being able to find insects all the year round, while the eastern one discovers very few during the winter. Insects probably are always preferred when obtainable.

Of insects eaten by the shrike, the largest item is Orthoptera—that is, grasshoppers and crickets—which amount to nearly 43 percent of the whole food. They are eaten in every month of the year, and in August and September reach nearly 70 percent. These are the normal grasshopper months, the ones in which Eastern birds enjoy their annual grasshopper feast. Ordinary grasshoppers form the greater part of this item of food, but a good many crickets are eaten, especially the brown and striped so-called wood crickets. One group of these is particularly noticeable—a group of large soft-bodied monsters of the genus Stenopelmatus, many of which live under dead leaves, stones, and rubbish, and do not often voluntarily show themselves by the light of day. It seems strange that the shrike, a lover of open and sunshine, manages to discover these creatures. They are sometimes called 'sand-crickets,' and perhaps at times come out into the open, but the writer has never seen one except when dug from under rubbish. It is not known whether these insects are harmful or beneficial, so the shrike's consumption of them has no economic interest. It is quite the contrary, however, with regard to grasshoppers, for they are harmful in all stages of existence, and the shrike is directly beneficial to the farmer to the extent that it destroys them.

Beetles collectively are second in importance in the shrike's diet. They amount to 16 percent of the food, but of this about 7 percent are the useful ground beetles (Carabidæ) and carrion beetles (Silphidæ). The rest are mostly harmful. The presence of these last is a curious point in this connection. These insects are probably useful, and while no great number of them are consumed, it seems rather strange that they are eaten at all. The surroundings of these beetles are not pleasant, and they do not generally serve as food for birds except crows and other garbage hunters. Is it possible that the shrike finds them on the game which it has hung on twigs or thorns? They were noted in 8 of the 124 stomachs, and three species were identified. Most of the beetles eaten by the shrike are of the larger species, but it does not disdain small game, and quite a number of small leaf-beetles and weevils were among the others.

Ants and wasps amount to something more than 11 percent in the diet of the shrike. Naturally they are mostly eaten in the warmer months, and the wasps far outnumber the ants.

Moths and caterpillars are taken to the extent of somewhat more than 7 percent, and seem to be a regular though small component of the food. Unlike the wasps, the greater number of these were eaten in the colder months. One stomach was entirely filled with the remains of 15 moths, a most unusual occurrence, for adult Lepidoptera do not form a large element of the food of any bird yet investigated.

Bugs and flies are eaten occasionally. The stomachs taken in February contained a good percentage of Hemiptera, and so did those collected in July. In one stomach remains of robber-flies (Asilidæ) were detected. This is a family of large predaceous flies, some species of which are said to prey upon honey-bees. These two orders and a few other odd insects constituted 5 percent of the food.

Spiders and several other kindred creatures form less than 2 percent of the food, but though not eaten in great numbers they appear in a good many stomachs. In one stomach was found one of those bristly and uncanny monstrosities of the order of jointed spiders (Solpugida). It is wonderful that any bird should attack one, still more that it should eat it, as it would seem to be about as palatable as a paper of pins. The lingual ribbon, or tongue, of a snail was found in one stomach, and bits of what appeared to be the limbs of small crustaceans in several. They did not amount to a noticeable percentage.

Vertebrates.—The vertebrate part of the shrike's food amounts to a little more than 12 percent, and consists of the remains of small mammals, birds, and lizards. Mammals were found in 4 stomachs, birds in 2, and lizards in 12. Neither of the birds could be identified further than that both were small song birds. Of the mammals, one was a pocket mouse (Perognathus), one a young field mouse (Microtus), and one a shrew (Sorex). The fourth mammal could not be identified, as there was little left except hair. The lizards were not recognizable either generically or specifically, as the remains consisted only of bones and scales. From an economic standpoint, lizards are useful animals, as they subsist on insects. The same is true of birds, so that in destroying birds and lizards the shrike is doing harm. Fortunately, it does not eat many birds. The destruction of the mammals is an unmixed blessing, except, perhaps, in the case of the shrew (Sorex), which is largely insectivorous. Even if all the above vertebrates were useful the score against the shrike would not be a very heavy one and would not outweigh the value of its services in destroying grasshoppers. In the writer's field experience with the shrike only one attempt to capture a vertebrate animal was observed. In this case the shrike was seen to plunge into a thicket of weeds in pursuit of a brood of tiny quail, but a few seconds later it emerged in a great hurry, closely followed by the irate cock quail. As a matter of fact, the noxious mammals eaten both by the eastern and western shrikes far outnumber the birds, and when to the former are added harmful insects the balance is very largely on the credit side.

FOOD OF YOUNG.

No nestlings of shrikes were at hand for investigation, but the stomachs of two young just out of the nest were examined. Both were filled with beetles, ants, wasps, and crickets. In a bird so thoroughly insectivorous as the shrike it is not probable that the food of the nestlings differs essentially from that of adults.

As a feature of the landscape and as lending animation to rural scenes the shrike in California is a pronounced success, and when one sees him jauntily balancing on a telephone wire it is pleasant to reflect that in his economic relations he is as admirable as he is from the esthetic point of view.

VIREOS.

The vireos are a group of rather small tree-haunting birds of plain colors, modest habits, and sweet but unobtrusive voices. One or the other of the several species inhabits pretty much everything in the way of a tree from the monarchs of the forest down to the humblest underbrush. In thickly settled country vireos inhabit gardens, orchards, and city parks, and shade trees along the village streets. Most of them are migrants, and leave the United States in winter, but a few remain on the Pacific coast throughout the year. Their food consists largely of insects, though a little fruit and some seeds are occasionally eaten.

In the insect diet of the vireos there is one element which constitutes a bar sinister on an otherwise brilliant escutcheon. All the species investigated show a decided taste for ladybirds—that is, coccinellid beetles. No other genus of birds, nor any single species (with one possible exception), so far has been known to manifest such fondness for these useful insects. In California the destruction of ladybird beetles is perhaps a greater crime than it would be in almost any other section of the country, for here the bark scales and plant-lice upon which these beetles feed are very destructive, and every device for their extermination has been employed, even to importing several foreign species of these predatory beetles.

Time was when the devastation of the San Jose scale and several other species of scale insects threatened the fruit industry of California, and there can be no reasonable doubt that the coccinellid beetles of both the imported and native species were largely instrumental in checking the spread of these pests. It is to be remarked that these beetles are wonderfully abundant in California, probably more so than any other family. The writer found them upon corn, weeds, grass, and bushes, often where apparently there was none of their natural food. In mitigation of the vireos' habit of eating ladybirds all that can be said is that where there is such a superabundance of the insects the damage is minimized.

The writer is glad to be able to add that besides the coccinellids, vireos eat many harmful insects, among which are the black olive scale. Here, then, is an instance where the bird eats the useful beetle and also its noxious prey. As there is nothing to indicate that the bird exercises a choice between them, we must infer that it eats both whenever it finds them. It eats the beetles and the food (scales) upon which they feed. From this point of view also it must be allowed that the harm done by the vireos in eating coccinellids is offset to some extent.

WESTERN WARBLING VIREO.

(*Vireo gilvus swainsoni.*)

One hundred and ten stomachs of the warbling vireo have been examined. They were collected during the seven months from April to October, inclusive, and though hardly as many as could be desired, they probably furnish a fair idea of the food during that portion of the year.

Vegetable food.—Insects, with a few spiders, amount to over 97 percent of the diet, leaving less than 3 percent of vegetable matter, practically all of which was taken in August and September; it consisted of wild fruit (elderberries), a few seeds of poison oak, a few other seeds, and some rubbish.

Animal food.—Of the animal food the largest item is Lepidoptera; that is, caterpillars, moths, and the like. These amount to something more than 43 percent of the whole. Caterpillars make up the great bulk of this portion of the food and are a very constant and regular article of diet. Fewer are eaten in July and August and more at the beginning and end of the season. In April they amount to over 82 percent of the food of the month. Pupæ of codling moths were identified in four stomachs, and minute fragments probably of the same were found in several others. A few adult moths also were found, but the species could not be identified.

Hemiptera are the next most important item of diet, and amount to 21 percent. They consist of stink-bugs, leaf-bugs, leaf-hoppers, spittle-insects, tree-hoppers, and scales. The last were the black olive species (*Saissetia oleæ*). Coccinellid beetles, or ladybirds, were eaten to the extent of over 19 percent of the whole. None was in the stomachs taken in October, while the greater part (over 63 percent) was contained in those obtained in July. The species belong to the genera Hippodamia and Coccinella, which are larger than those of the genus Scymnus selected by the warblers. Other beetles, mostly harmful species, amount to more than 7 percent.

Hymenoptera, which are an important food of the warblers, are conspicuous by their absence in the stomach of the warbling vireo. A little more than 1 percent represents the sum total. They consist of a few ants and an occasional wasp.

A small number of flies, grasshoppers, and dragon-flies make up a little more than 3 percent of the miscellaneous insects. Spiders were eaten to somewhat less than 2 percent.

CASSIN VIREO.

(*Vireo solitarius cassini.*)

This is another of the tree foragers living in summer in orchards, canyons, and forests.

Its food consists of the same elements as that of the last-described species, but in somewhat different proportions. Forty-six stomachs were examined, taken in every month from April to November. They afford at least a fair indication of the food for those months.

Vegetable food.—The vegetable food, which was only a little more than 2 percent of the total, was made up of leaf galls, seeds of poison oak, and a few bits of rubbish. Not a trace of fruit was found.

Animal food.—The animal matter amounts to nearly 98 percent of the whole. Hemiptera are the largest item and amount to nearly 51 percent. The various families represented are those of the squash-bugs, leaf-bugs, stink-bugs, shield-bugs, leaf-hoppers, tree-hoppers, the jumping plant-lice, and scales. The latter are represented as usual by the black olive scale, which was contained in four stomachs. Caterpillars, with a few moths, are next in importance and form more than 23 percent of the whole food. They were eaten in every month and are evidently a favorite diet.

Hymenoptera are eaten much more largely by this species than by the last. They amount to over 7 percent, and are mostly wasps, with a few ants. This record, however, is likely to be modified by further investigation.

Ladybird beetles were eaten to the extent of a little less than 6 percent, which is quite reasonable as compared with the record of the warbling vireo. It is, however, much greater than that of any bird outside the present genus, except the pygmy nuthatch, and in the case of that bird the evidence is too meager to be accepted at its face value. Other beetles amount to a little more than 3 percent of the food, and are mostly weevils and small leaf-beetles (Chrysomelidæ). A few flies, grasshoppers, and other insects amount to somewhat more than 2 percent, and these, with 4 percent of spiders, make up the remainder of the animal food.

SUMMARY.

In glancing over this record of the Cassin vireo it appears that bugs are the favorite food, as shown by the numbers consumed; but caterpillars, though second in quantity, are eaten with greater regularity and appear in the food of every month. The consumption of ladybirds is very moderate for a vireo, and on the whole the bird probably does not do much harm in this way. All the other beetles are harmful, as are most of the other insects which compose the bird's food.

HUTTON VIREO.

(*Vireo huttoni.*)

This species is a resident of most parts of California west of the great interior valley. In food habits it does not differ remarkably from the foregoing, but the various elements of its food are in slightly different proportions.

Vegetable food.—Examination of 54 stomachs shows that less than 2 percent is composed of miscellaneous articles of vegetable origin. One stomach contained a few seeds of elderberries, two contained those of poison oak, and these with a few galls and some rubbish make up the whole of this part of the food. It would seem that with most of the vireos vegetable matter is taken accidentally, or possibly experimentally to see how it tastes, rather than as an approved article of diet.

Animal food.—Of the 98 percent of animal food the largest item is Hemiptera, as is the case with many of the vireos, titmice, and gnatcatchers. These insects amount to 49 percent of the food of the present species, and are represented by the following families: Assassin-bugs, leaf-bugs, stink-bugs, leaf-hoppers, tree-hoppers, jumping plant-lice, and bark scales. These last consist, as is so often the case, of the black scale, which appeared in 8 stomachs. Caterpillars, with a few moths and cocoons, are next in importance, and constitute over 22 percent of the food. These two items not only make up more than two-thirds of the diet, but are eaten with great regularity through the year and seem to be the staples of the bird's food.

Beetles, collectively, amount to nearly 11 percent. Of these 8 percent are ladybirds, somewhat more than were eaten by the Cassin vireo, but only half of the amount eaten by the Swainson vireo. The remaining beetles, less than 3 percent, were largely weevils, among which a few engravers (Scolytidæ) could be distinguished. Hymenoptera, including both wasps and ants, form about 7 percent of the food. Among them several parasitic ones were identified, but there were not enough to be of any great economic interest. A few miscellaneous and unidentified insects amount to nearly 5 percent of the food. Flies and grasshoppers make up a part of this, but they are only rarely eaten. Spiders are consumed regularly but sparingly. They amount to a little more than 2 percent.

OTHER CALIFORNIA VIREOS.

Several other species and subspecies of vireos occur in California, but in the general character of their food they agree closely with the foregoing.

BEETLES FOUND IN STOMACHS OF VIREOS.

Coccinella t. californica.
Hippodamia convergens.
Scymnus spp.
Agrilus spp.
Crepidodera helxines.
Gastroidea viridula.
Blapstinus spp.
Apion cribricollis.
Balaninus spp.
Copturodes koebelei.

WARBLERS.

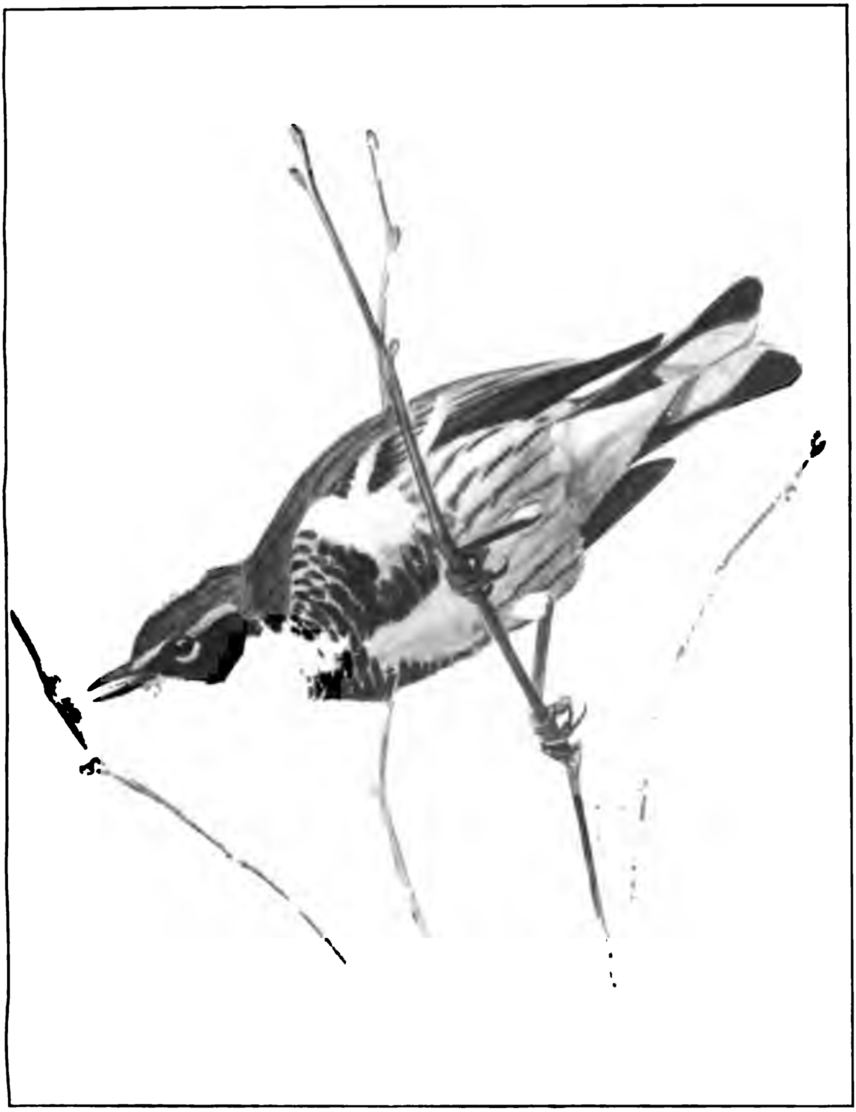
(Mniotiltidæ.)

The warblers, or more properly the wood warblers, to distinguish them from the warblers of the Old World (Sylviidæ), are a large family of rather small and often brightly colored birds. For the most part they inhabit woods and shrubbery, and while some of them obtain their food from the ground they seldom wander far from trees and bushes. The species and subspecies are so widely distributed that, excepting the deserts, there are no very extensive areas within the boundaries of the United States that do not have their complement of these interesting birds. Their food consists largely of insects, and they subsist upon species which frequent the leaves and trunks of trees. Wasps and flies (Hymenoptera and Diptera) form a large portion of their diet, and as these insects are the best of fliers a considerable portion of them are taken on the wing. The warblers probably eat more of these elusive insects than does any other family of birds except the flycatchers (Tyrannidæ) and the swallows.

Upward of 75 species and subspecies of warblers are known within the limits of the United States, and a majority of these occur in the West, though perhaps they are not so abundant individually as in the Mississippi Valley and Appalachian region.

The genus Dendroica, as the one best exhibiting the characteristic traits of the group, may be taken as the type of the family. There are about 30 species and subspecies of the genus in this country, and the ones whose food is discussed in the following pages occur in California and on the Pacific coast generally.

In a résumé of the food of the warbler family one is impressed with the general noxious character of the insects which compose it. The order of Hemiptera, commonly called bugs, contains some of the worst insect pests that afflict mankind. Moreover, from their small size and unobtrusive habits they are not eaten by many of the larger birds and are difficult to exterminate by the devices of man. But in some of their multiple forms they are preyed upon by the warblers



AUDUBON WARBLER (DENDROICA AUDUBONI).

to an average extent of more than 25 percent of the whole food. Most of the other insect food, also, is either of a noxious or neutral description, and the vegetable portion is so small that it may be disregarded. There is probably no finer tribute to the beneficial character of these birds than that of Dr. Elliot Coues, who says:

> With tireless industry do the Warblers befriend the human race: their unconscious zeal plays due part in the nice adjustment of Nature's forces, helping to bring about the balance of vegetable and insect life, without which agriculture would be in vain. They visit the orchard when the apple and pear, the peach, plum, and cherry, are in bloom, seeming to revel carelessly amid the sweet-scented and delicately-tinted blossoms, but never faltering in their good work. They peer into the crevices of the bark, scrutinize each leaf, and explore the very heart of the buds, to detect, drag forth, and destroy these tiny creatures, singly insignificant, collectively a scourge, which prey upon the hopes of the fruit-grower and which, if undisturbed, would bring his care to naught. Some Warblers flit incessantly in the terminal foliage of the tallest trees; others hug close to the scored trunks and gnarled boughs of the forest kings; some peep from the thicket, the coppice, the impenetrable mantle of shrubbery that decks tiny watercourses, playing at hide-and-seek with all comers; others more humble still descend to the ground, where they glide with pretty, mincing steps and affected turning of the head this way and that, their delicate flesh-tinted feet just stirring the layer of withered leaves with which a past season carpeted the ground.[a]

Following is a list of insects, mostly beetles, identified in the stomachs of the warblers examined. A number of these had been eaten by nearly every species:

COLEOPTERA.

Coccinella t. californica.
Scymnus pallens.
Scymnus marginicollis.
Scymnus sp. nov.
Microlipus laticeps.
Melanophthalma americana.
Aphodius rugifrons.
Diachus auratus.
Gastroidea cyanea.
Diabrotica soror.
Crepidodera helxines.
Epitrix parvula.
Bruchus pauperculus.
Blapstinus pulverulentus.
Notoxus alamedæ.
Anthicus difficilis.
Diodyrhynchus byturoides.
Apion vespertinum.
Onychobaris insidiosa.
Balaninus sp.

HEMIPTERA.

Saissetia oleæ.
Aspidiotus rapax.

AUDUBON WARBLER.

(*Dendroica auduboni.*)

(Plate III.)

The Audubon warbler is well distributed over the Pacific coast region, breeding in the mountains and descending in winter to the valleys and plains of California. It is one of the most abundant species, and may be considered as typical of the genus, especially in the matter of food. In the winter season it is a frequenter of orchards, gardens, and dooryards where it pursues its business of insect hunting with a persistent assiduity worthy of all praise. At this season it is very familiar and easily approached.

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[a] Birds of the Colorado Valley, p. 201.

In investigating the food of the Audubon warbler 383 stomachs have been examined. They were taken from July to May inclusive. Geographically they are distributed from the San Francisco Bay region southward to San Bernardino, and probably give a fair idea of the winter diet of this bird in California. The food consisted of nearly 85 percent of animal matter (insects and spiders) and a little more than 15 percent of vegetable.

Animal food.—The largest item of animal food is Hymenoptera—wasps and ants—which aggregate a little more than 26 percent of the whole. By far the greater number of these are ants, and as plant-lice also are eaten to a considerable extent, it is probable that many of the ants are species that take care of the lice. The other members of this order are mostly rapid fliers, so the inference is that they were caught on the wing. The greater number were eaten in the fall and spring months. In our record May appears as the month of least consumption—6 percent. August is the month of greatest consumption—61 percent. This record, however, probably is unreliable, as but one stomach was taken in this month. A few were identified as belonging to parasitic species.

Flies (Diptera) are represented in the stomachs of the Audubon warbler to the extent of a little more than 16 percent, or one-sixth of the whole food. This is one of the largest, if not the very largest, record of this order of insects eaten by any bird except some of the swallows. Even the so-called flycatchers do not eat so many flies as this warbler—in fact, the name 'wasp-catchers' would be much more appropriate for that family. The flies eaten by the Audubon warbler must have been caught in mid-air, for flies as a rule do not allow themselves to be captured without at least attempting to escape. These insects are so soft-bodied that it is not often possible to determine more about them than that they are Diptera. Two families were identified—Muscidæ, the family of the common house fly, and Tipulidæ, or crane-flies, the long-legged mosquito-like creatures otherwise known as "daddy-long-legs." Most of the Diptera, however, are the smaller species, such as gnats, which fly in swarms, and being rather sluggish are more easily captured. They are eaten with remarkable regularity during the whole season, with no decided decrease in the winter months—in fact, more were eaten in January than in either September or April. March is the month of maximum consumption, when Diptera constitute over 54 per cent of the whole food.

Bugs collectively amount to nearly 20 percent, of which a little more than 4 percent are scales and plant-lice. The black olive scale (*Saissetia oleæ*) and another species (*Aspidiotus rapax*) were found in 15 stomachs. Plant-lice (Aphididæ) were contained in 39 stomachs, and from the numbers eaten appear to be favorite food. Several stomachs were entirely filled with them, and the stomachs in which they were found contained an average of 71 percent in each. The remainder of the hemipterous food, more than 15 percent, is made up of stink bugs, leaf-hoppers, and tree-hoppers, with a considerable residue of other remains not further identified. Bugs, as a whole, are eaten rather irregularly, and the greater number are eaten in the fall months, after which the number consumed gradually decreases. Caterpillars are eaten rather regularly by the Audubon warbler, but not in great numbers. They amount to nearly 14 percent of the food of the season, though this figure includes a few moths and chrysalids. Some cocoons of tineid moths were in several stomachs.

Beetles of all kinds aggregate something more than 6 percent of the whole diet. They belong to several families, but the snout-beetles are most prominent. The others belong to about a dozen families, and, except a few carrion and ladybird beetles, are injurious. A few insects other than the above and some spiders, in all a little less than 2 percent, make up the rest of the animal food.

Vegetable food.—The vegetable food of the Audubon warbler consists of fruit, weed seed, and a few miscellaneous substances. As the bird does not visit the fruit-growing regions during the fruit season, it is not chargeable with injury to cultivated crops. Almost all the fruit eaten is wild and of no value, though in the fall it probably feeds to some extent upon various belated products of the orchard. The total of fruit for the season is less than 5 percent, of which the greater amount is eaten in the autumn and early winter, after which the quantity is unimportant.

The most prominent item of vegetable diet, however, is weed seed. This is eaten to the extent of a little more than 9 percent of the whole food, and is taken in almost every month of the bird's stay, the greater quantity in winter. Something more than 31 percent was eaten in December, 22 in January, and 31 in February, after which it decreases regularly to April. One of the most important seeds eaten by the Audubon warbler is that of the poison oak (*Rhus diversiloba* (Pl. II, fig. 9). In most cases the whole seed is not eaten by this bird, but only the waxy outer coating, which is easily identified by certain woody granules which it contains; hence the bird does not aid in the distribution of these noxious plants. The remaining vegetable food, amounting to less than 2 percent, consists principally of rubbish.

SUMMARY.

It must be evident to the most casual reader that this bird is a valuable asset in the orchard and garden. The great bulk of its food, both animal and vegetable, is composed of elements the elimination of which from the farm is a benefit. As has been elsewhere pointed out, the destruction of insects during winter or in early spring is more useful than in the height of the midsummer abundance, for in spring the progenitors of the season's broods are destroyed and with them the possibility of thousands of progeny.

MYRTLE WARBLER.

(*Dendroica coronata.*)

This is another winter visitant in California. Only 10 stomachs of this species have been examined, but the contents show the predominant food characteristic of the genus. There is one point, however, which is worthy of passing note. One of these stomachs was completely filled with greedy scales (*Aspidiotus rapax*), with the exception of a small fragment of a beetle; another contained remains of the black olive scale, and still another some scales not identified.

TOWNSEND WARBLER.

(*Dendroica townsendi.*)

The Townsend warbler, like the Audubon, summers in California only in the mountains. During the migration and in winter it visits the valleys. Like other members of the family it is an insect eater almost exclusively, and does not eat fruit or other farm products. Thirty-one stomachs were taken in the four months from October to January inclusive, in the region from Pacific Grove to Watsonville.

As our stomach examinations disclose the fact that the food of this warbler agrees closely with that of others of the same group, a fair idea of the diet for the above months is obtained.

Animal food.—The animal food consists of insects and a few spiders, and amounts to over 95 percent of the food during the time specified. Of this, bugs make up 42 percent, mostly stink-bugs (Pentatomidæ) and a few leaf-hoppers and scales. The former appear to be a favorite food. Although these insects are eaten with considerable regularity by most of the warblers of this group, they are not usually taken in great numbers, but the Townsend warbler eats many, and several stomachs were entirely filled with them.

Hymenoptera, consisting of both wasps and ants, are eaten to the extent of 25 percent of the food. Most of them are winged species. Perhaps the most striking point in the food of this bird is the great number of weevils or snout-beetles represented. They amount to over 20 percent of the food, while all other beetles form less than 1 percent. The greater number of these insects were of the species *Diodyrhynchus byturoides*, a weevil which destroys the staminate blossoms of coniferous trees. Five stomachs contained, respectively, 68, 65, 53, 50, and 35 of these beetles, or 271 in all. Moreover, each of these stomachs contained fragments which could not be satisfactorily identified; probably these were the same species, so that the total contained in the 5 stomachs is probably nearer 300. Several other stomachs contained fewer of these weevils. Representatives also of another family of snout-beetles very destructive to timber were present in a few stomachs. These were the engravers (Scolytidæ), which lay their eggs beneath the bark of trees, where they hatch, and the larvæ bore in every direction. Caterpillars and a few miscellaneous insects and some spiders make up the remainder of the animal food.

Vegetable food.—The vegetable matter, which amounts to less than 5 percent of the whole, consists of a few seeds and leaf galls. As the galls in most cases contained small larvæ it is a question if they should not be reckoned as animal food.

SUMMARY.

While this can be considered as only a preliminary study of the food of the Townsend warbler, the thoughtful reader can not fail to be impressed by the fact that this bird exhibits some very valuable economic traits, especially in its relation to the forest. The stomachs containing the pine-eating weevils were from birds killed in the pine forests of Pacific Grove, near Monterey, as also were those containing the engraver beetles. Of the 30 stomachs examined, 19 held the remains of weevils, from which it would appear that these insects are preferred as an article of food. As this group of beetles contains some of the worst pests of the forest and orchard, any bird that eats them so freely must be considered as performing a most welcome service.

SUMMER WARBLER.

(*Dendroica æstiva* subspp.)

The summer warbler, yellow warbler, or summer yellowbird, as it is variously called, is represented in the West by two subspecies, one of which visits California only as a migrant. The other, which does not differ essentially from the eastern form, is a rather common summer resident throughout the valley and foothill regions. In the East this bird is fairly domestic in its habits, and may often be seen about gardens and orchards, or in rose bushes nearer the house. In California it is not quite so familiar, but is becoming so and probably will soon acquire the habits of its eastern relative. From the material at hand this warbler appears to be even more exclusively insectivorous than the species last discussed. This may arise from the fact that it stays in the fruit districts during summer, when insects are most numerous; but it must be remembered that this is also the season when fruit and vegetable food generally are most abundant.

William Prond, of Chico, Butte County, thus recounts the efficient service of this and other warblers:

> On Rancho Chico is a fine collection of roses, all of which are more or less liable to attacks from *Aphis rosea*, but are perfectly free from other insects. I attribute this to the protection of small birds, among the most active of which are *Dendroica æstiva*, * * * *Helminthophila celata*, *Regulus calendula*.

The following statements in regard to the food of the summer warbler are based on the examination of 98 stomachs, all collected from April to October, inclusive.

Animal food.—The animal food, composed entirely of insects and a few spiders, amounts to over 97 percent. The largest item is Hymenoptera, which amounts to over 30 percent, about half of which are ants. The remainder are small bees and wasps, some of which are probably parasitic species, though none were positively identified. The insects of this order must be favorite food, as they are eaten with remarkable regularity and constitute an important percentage of the diet in every month represented. Caterpillars, with a few moths, aggregate over 18 percent. The greater number are eaten in spring and early summer, but in fall they give place to other insects.

Beetles form nearly 16 percent of the diet, and embrace about a dozen families, of which the only useful one is that of the ladybirds (Coccinellidæ), which are eaten to a small extent. The great bulk of the beetle food consists of small leaf-beetles (Chrysomelidæ), with some weevils, and several others. One stomach contained the remains of 52 specimens of *Notoxus alamedæ*, a small beetle living on trees. Bugs (Hemiptera) constitute over 19 percent of the food, and are eaten regularly every month. Most of them consist of leaf-hoppers (Jassidæ) and other active forms, but the black olive scale appeared in a number of stomachs. Plant-lice were not positively identified, but some stomachs contained a pasty mass, which was probably made up of these insects in an advanced stage of digestion.

Flies seem to be acceptable to the summer warbler; they are eaten to the extent of nearly 9 percent. Some of them are of the family of the house fly, others are long-legged tipulids, but the greater number were the smaller species commonly known as gnats. A few small soft-bodied Orthoptera (tree-crickets), a dragon-fly, and a few remains not identified, in all about 5 percent, made up the rest of the animal food.

Vegetable food.—The vegetable portion is only about 2½ percent. Nearly all of this was fruit pulp contained in a single stomach. This, with one or two seeds and a few accidental bits of rubbish, makes up the whole vegetable contingent, which, therefore, may be dismissed without further comment.

FOOD OF NESTLINGS.

Some idea of the amount of insect food eaten by warblers may be obtained by watching the feeding of their young by the parent birds. A nest of the summer warbler containing two young, about a week old when discovered, was watched for six hours distributed over three days. The nest was situated in a prune tree in an orchard, and it is practically certain that all the food for this family was obtained in the orchard. The results of the observation appear in the following table:

Date.	Forenoon.		Afternoon.	
	Hour of observation.	Number of feedings.	Hour of observation.	Number of feedings.
June 12	....	....	3.26–4.26	21
June 14	8.21– 9.21	31	....	....
June 14	10.34–11.34	32	4.36–5.36	31
June 15	8.00– 9.00	36	1.11–2.11	30

In six hours 181 feedings were observed, an average of 30⅙ per hour. As there were only two young, it follows that each nestling was fed 15 times per hour, or for a day of fourteen hours 210 times. Both parent birds took part in feeding the young, but it was noted that the female visited the nest most frequently.

SUMMARY.

From the above facts it is evident that the presence of a few warbler nests in an orchard goes far to safeguard the trees from attacks of insect enemies. The inference is plain that the presence of insectivorous birds should be encouraged by the orchardist by every means in his power. The summer warbler is, if possible, even more completely beneficial in its food habits than the Audubon warbler. Its animal food in relation to man is almost entirely noxious or neutral, and it eats so little vegetable food that its character is of but slight consequence.

WESTERN YELLOWTHROAT.

(*Geothlypis trichas* subspp.)

In California the yellowthroat is an inhabitant of marshes and low, bushy places among tules or willows. While it is an insect eater of the highest order, it does not so directly affect the interests of horticulture as it would if it frequented orchards and gardens. It may be said, however, that as the swamps and thickets in which it lives are the recruiting grounds for many orchard pests, the bird that destroys them in their native haunts is by no means without economic value.

In a somewhat restricted investigation of the food of this bird 114 stomachs, taken in every month except January, were examined.

Vegetable food.—A few seeds and bits of rubbish is the sum total of the vegetable food, and it is probable that these were taken accidentally. Some of the ants of California store up seeds, and when snapping up ants the yellowthroat probably takes the seeds along with them.

Animal matter.—The animal matter amounted to 99.8 percent of the total food. The largest item is Hymenoptera, amounting to 35 percent, of which about half is ants and the remainder wild bees, wasps, etc.

Hemiptera amount to 28 percent, and are made up of leaf-bugs, leaf-hoppers, tree-hoppers, plant-lice, scales, and probably some others not identifiable. The black olive scale was found in a few stomachs and plant-lice in one, but the other families were a pretty constant component of the food in every month.

Beetles were eaten to the extent of nearly 15 percent, and are mostly harmful species, the exception being a few coccinellids of the genus Scymnus, which, however, do not amount to 1 percent of the whole. Weevils and others of the more common families make up the rest of this portion of the diet. The three orders of insects mentioned above form the great bulk of the food of the yellowthroat, and are regularly eaten throughout the year.

Caterpillars and moths comprise 5 percent, but, so far as the stomachs at hand show, are eaten very irregularly and do not appear on the preferred list. The same may be said of Diptera, though they amount to 12 percent, but in several months none were eaten. Grasshoppers were found in only four stomachs, but one of these contained nothing else. Spiders are taken to the extent of nearly 4 percent, but in some months none were found and only a trace in others.

SUMMARY.

From the above rather brief survey of the food of the yellowthroat it is evident that the horticulturist has nothing to fear from this bird should it change its habitat and become an inhabitant of orchards and vineyards. It is practically wholly insectivorous, and the insects it eats are either harmful or of little economic value. It eats no fruit or grain, nor, so far as known, any other useful product. Like other members of the family, its life is passed in unceasing search for insects.

ORANGE-CROWNED WARBLER.

(*Helminthophila celata* subspp.)

The genus Helminthophila is next to Dendroica in the number of species and subspecies it contains, but still falls far below it. Several species occur in California, but the one under consideration is probably the most important. Only 65 stomachs were available for examination, but they confirm the evidence already obtained from other species.

Vegetable food.—Less than 9 percent of the food is vegetable matter, and is made up of 3 percent of fruit and rather more than 5 percent of various substances, such as leaf galls, seeds, and rubbish. Fruit was found in only a few stomachs, but the percentage in each was considerable; figs were the only variety identified.

Animal food.—The animal matter in these stomachs amounts to 91 percent of the food. Hemiptera are the largest item and amount to over 25 percent, mostly leaf-bugs, leaf-hoppers, plant-lice, and scales. Plant-lice were found in only one stomach and scales in 5, of which 3 contained the black olive species. Beetles amount to about 19 percent of the food, and with the exception of a few Coccinellidæ are of harmful families, among which are a number of weevils.

Beetles and bugs are the two orders of insects that are not only eaten to the greatest extent but are taken with great regularity, and form a respectable percentage of the food in every month.

Caterpillars are eaten rather irregularly, though they aggregate 24 percent for the year. Stomachs collected in several months contained none, while in others they amounted to more than half the food. Probably the examination of a greater number of stomachs would show more regularity in the consumption of these insects.

Hymenoptera amount nearly to 15 percent, and are mostly small wasps, though some ants are eaten. This is the smallest percentage for this order that has yet been found in the food of any warbler.

Flies are represented by less than 1 percent, which is unusually small. Perhaps this warbler lacks the skill to catch such agile insects. Seven percent of spiders were found in the stomachs, the largest percentage of these creatures for any warbler. This again indicates that the orange-crown is most successful in hunting sluggish game, such as beetles, bugs, and spiders.

GOLDEN PILEOLATED WARBLER.

(*Wilsonia pusilla* subspp.)

The golden pileolated warbler is another of the small birds that summer here and there on the Pacific coast, mostly in willows and other shrubbery, but not rarely in the orchard. During the migration it is common and widespread.

Fifty-two stomachs of this bird have been examined, and though the evidence is somewhat fragmentary, it suffices to reveal the general character of the food.

Animal food.—Animal matter amounts to over 93 percent, vegetable to less than 7 percent. Of the former, the larger item is Hemiptera. which aggregates over 35 percent. The black olive scale was found in four stomachs, but leaf-hoppers make up the bulk of this portion of the food. Hymenoptera stand next in importance, with 31 percent, made up of both wasps and ants.

Flies are eaten to the extent of 11 percent, and in connection with the Hymenoptera proves what observation of its habits indicate, that this bird gets much of its food when on the wing. A good many of the insects were the tipulids, or crane-flies.

Beetles of half a dozen different families were eaten to the extent of about 9 percent. They were mostly leaf-beetles (Chrysomelidæ), with a few weevils and one or two others. No coccinellids were found.

Somewhat less than 5 percent of the food consists of caterpillars. They do not appear to be favorite food, for they are eaten very irregularly. Spiders also are taken only sparingly, and form but little more than 1 percent of the total food.

Vegetable food.—The vegetable food, less than 7 percent of the total, is made up almost entirely of fruit pulp, and was eaten in the months of September and October.

SUMMARY.

The foregoing hasty review of the food of the golden pileolated warbler shows that its food habits are practically the same as those of other members of the family. The food is largely composed of insects, and its two most prominent elements are Hymenoptera and Hemiptera, which are eaten extensively and very regularly through the year. The other components of the diet apparently are taken with less regularity.

WESTERN MOCKING BIRD.

(*Mimus polyglottos leucopterus.*)

The mocking bird has always been held in such high esteem as a singer that perhaps it would be useless to attempt to add to the bird's repute by showing that its food habits are of a high order of economic interest. Moreover, the title of the mocking bird to be ranked as an economic benefactor is not quite clear, for, though it does considerable good by the destruction of harmful insects, it eats much fruit, and from the Southern States, particularly Texas and Florida, where fruit raising is an important industry, have come bitter complaints against it. In Florida the bird is said to attack grapes and oranges, and in Texas it is asserted that figs are to be added to its food list.

In California the mocking bird is a common resident only in the southern half of the State and is very common only in restricted portions. No serious complaints of the bird's depredations in this State have yet been made, but this perhaps is due to the fact that mocking birds are rare in sections where cherries and the smaller deciduous fruits are grown. Where mockers are most abundant, citrus fruits are the principal crop and the birds do not appear to molest them.

While a number of stomachs of this bird have been examined, they are too few and too unequally distributed over the region under investigation to justify final conclusions with regard to the animal food; still they furnish information of value. It so happens that 33 stomachs were taken between July 18 and August 18, and another a few days later. All but one of these stomachs were from the region about Los Angeles, and this one was collected at Fresno. The average, therefore, is a little more than one stomach a day for this period, and gives a fair idea of the food for the time and locality.

The first analysis gives 23 percent of animal matter and 77 percent of vegetable. There was no stomach which did not contain some vegetable food, while 10 had no animal matter.

Animal food.—Beetles of several families formed a little less than 1 percent. Hymenoptera, largely ants, were eaten to the extent of somewhat more than 10 percent. Grasshoppers constituted the largest item of animal food, and amounted to 11 percent of the whole. A few caterpillars and spiders made up the other 1 percent of the animal food.

Vegetable food.—Of the 77 percent of vegetable food nearly 74 percent was diagnosed as fruit. Some of this, of course, was wild, but blackberries or raspberries, grapes, and figs were found in many stomachs. Many of the birds were taken in orchards and gardens, and some were shot in the very act of pilfering blackberries. Others were taken in a wild arroyo away from cultivation. The only species of wild fruits that were identified were elderberries, which were found in a few stomachs. The other vegetable matter was made up of several elements. Of these, the seeds of poison oak (Pl. II, fig. 9) are perhaps the most conspicuous, and one stomach was entirely filled with them. A few weed seeds and some rubbish completed the vegetable part of the food.

Besides the 34 stomachs already discussed, 19 others were examined, but as they represent nine months of the year they are too few to afford a criterion of the usual food for those months; but they give a hint at least of what is eaten at other times than midsummer. Two stomachs were taken in March, one of which was filled with animal food, and the other also, except 1 percent of vegetable rubbish. The animal portion consisted of harmful insects, except one lizard. This seems peculiar food for a mocking bird, and is to be considered beneficial. The one stomach taken in May was filled with seeds of poison oak. A stomach collected in June contained 8 percent of caterpillars; small fruit, probably wild, constituted the rest of the contents. Six stomachs taken in August contained 22 percent of animal matter to 78 of vegetable. The animal food consisted of beetles, ants, and grasshoppers. The vegetable portion was made up of some wild grapelike fruit and a little fig pulp with some elderberries. Of four stomachs taken in September, one was filled with insects and spiders. The three others contained a few wasps, with fruit and other vegetable matter. The only insect to be considered useful was one carabid beetle. Of the three stomachs collected in October, one was filled with the seeds and pulp of grapes and figs; one contained 27 percent of grasshoppers and 73 percent of some wild berry not positively identified, while the third contained a few grasshopper remains and 92 percent of wild seed. The stomach collected in December was filled with seeds and pulp of figs and grapes. One stomach was taken in January which contained 70 percent of harmful insects and 30 percent of seeds of poison oak.

FOOD OF YOUNG.

Among these stomachs was one of a nestling about a week old. It contained 92 percent of grasshoppers and crickets and 8 percent of some wild fruit. So far as it goes, this indicates that mockers follow the general rule and feed their young largely on animal food of the softer kind—that is, grasshoppers instead of beetles.

SUMMARY.

Reviewing the contents of the 52 stomachs we find 29 percent of animal matter and 71 of vegetable. Of the animal food the largest item is Hymenoptera, 10 percent, and then in order, Orthoptera 7 percent, Coleoptera 6 percent, Lepidoptera 5 percent, miscellaneous 1 percent. The vegetable food consists of 50 percent of fruit and 21 percent of seeds and other items. These results prove that the mocking bird eats insects to a considerable extent, but they are not conclusive as to the elements of its preferred diet. It is evident that it is fond of fruit, and where abundant the bird may become a menace to the orchard and vineyard.

CALIFORNIA THRASHER.

(*Toxostoma rediviva.*)

Thrashers are eminently birds of the underbrush. While they occasionally alight on trees at some height from the ground, they are more frequently seen under bushes or skulking out of sight in some almost impenetrable thicket of briars. When, however, the thrasher wakes in the morning and feels his soul overflowing with song, he perches on the topmost twig of a tree and lets the world know that he is there and believes that life is worth living.

The food of the thrasher is obtained on or near the ground. The long curved bill of the California species is probably used much as many birds use their claws to dig among dead leaves and other rubbish for insects. The bird is not fastidious in its diet, and examination of the stomachs reveals a good many bits of dead leaves, rotten wood, plant stems, which are carelessly taken along with more nutritious morsels.

An examination of 82 stomachs of this species shows that vegetable food exceeds the animal in the proportion of 59 to 41. In the eastern species (*T. rufum*) the ratio is 36 to 64. This result is rather surprising, for, as a general rule, California birds eat a larger proportion of animal food than do the most nearly related eastern species.

Animal food.—As the thrasher is eminently a ground forager it would naturally be expected to find and eat many ground-living beetles. Of these the Carabidæ are the most important, owing to their predaceous habits; so a separate account of this family was kept. The result shows that they enter the food of the thrasher to the extent only of 3.8 percent, while all other beetles amount to nearly 6 percent. Of these, the darkling beetles (Tenebrionidæ) are the most numerous, and the May beetles (Scarabæidæ) next. But very few weevils or other species that live on trees or foliage were found. Of all the insects, Hymenoptera are the most abundant, as they are also the most constant element of the thrasher's food. About half of these are ants, the rest wasps and bees. Ants naturally are the insects most often found by this bird, as many species live on the ground and among rubbish and rotten wood. The occurrence in the food of wasps and bees, on the contrary, is somewhat of a surprise, as they are mostly sun-loving insects more often found on flowers or the leaves of trees than under bushes or thickets where the thrasher delights to forage. Together they make up something more than 12 percent of the food of the year. Two specimens of worker honey-bees (*Apis mellifera*) were found in one stomach. None of the other Hymenoptera was of specially useful species.

Caterpillars, cocoons, and moths amount to a little more than 8 percent of the food, and the greater number were eaten during the winter months. It is probable that they were hibernating and were raked out from under dead leaves or other rubbish. A few bugs, flies, grasshoppers, and spiders make up the rest of the animal food—about 6 percent. Spiders and myriapods amount to a little more than 6 percent.

Vegetable food.—The vegetable food may be divided into three parts: Fruit, poison-oak seeds, and miscellaneous vegetable matter. Fruit represents nearly 18 percent, but it probably is not of much value. Several stomachs contained pulp that could not be identified with certainty, and might have been that of some cultivated variety. Seeds of Rubus fruits (blackberries or raspberries) were found in 12 stomachs out of the 82. These, however, are as likely to have been wild as cultivated. Elderberry seeds were discovered in 10 stomachs, Cascara, or coffee berries (*Rhamnus californicus*), in 5, and manzanita berries in 1. The seed of poison oak (*Rhus diversiloba*, Pl. II, fig. 9), and a few of the nonpoisonous species of Rhus were eaten to the extent of 14 percent of the food. They were not found in many stomachs, but appear to be eaten in considerable quantities, when eaten at all. The thrasher must be added to the list of birds that assist in the dissemination of the seeds of this noxious plant.

The miscellaneous part of the vegetable food amounts to over 26 percent, and is made up of mast, weed seed, galls, and rubbish. The mast was not further identifiable. Most of the seeds were so broken and ground up that only a few species were identified. Two stomachs contained remains of grain—wheat in one and corn in the other. Leaf galls were found in several stomachs, and rubbish in quite a number, though here again it is difficult to draw the line between food proper and stuff that is accidentally picked up with it.

SUMMARY.

Although the thrashers eat some fruit, most of it is wild and of no value. Moreover, the bird's habits are such as to preclude the likelihood that it will ever become a resident of orchards. Grain evidently is not a favorite food, and if it were it is doubtful if the bird would leave its chosen haunts for the sake of procuring it. It is not probable that the California thrasher will ever become of special economic interest unless under very exceptional circumstances. In the meantime it performs its part in the great work of reducing the vast numbers of insects.

WRENS.

Since the time to which history runneth not the wren family, represented by one or other of its members, has attached itself to the abodes of man. Wherever man settles some member of this group is ready to greet him, to take advantage of his improvements, and to aid in the fight against his insect enemies. The common wren of Europe and the house wren of eastern North America habitually choose crannies in buildings or fences for nesting places, or if hollow trees are selected they usually are near human dwellings, preferably fruit trees in orchards or gardens. When civilization was pushed to the Pacific coast, wrens were there ready to welcome the new order of things. In food habits the wrens proper (Troglodytinæ) are largely insectivorous. While occasionally they eat a seed or a bit of fruit, the quantity taken by most species during the year is so small in comparison to the animal portion as to be insignificant. The insects eaten by the wrens are mostly noxious species, such as infest the foliage and branches of trees and shrubs, and the domestic habits of the wrens enable them to attack these pests in the very places where they are most harmful—that is, in the garden and orchard. The predaceous beetles (Carabidæ), which live mostly on the ground, are protected from the wrens by this very habit, as the latter seldom forages in such places. Moreover, the species most valuable to man are rather large prey for such small birds.

BEWICK WREN.

(*Thryomanes bewicki* subspp.)

The Bewick wren is one of the species which to a considerable extent occupies in California the place of the house wren in the Eastern States. The nesting habits of the two are practically identical, and the economic value of the former is just as great as that of the latter.

Investigation of this bird's food is based upon the examination of 146 stomachs taken in every month of the year. Of its diet for the year a little more than 97 percent consists of insects and less than 3 percent of vegetable matter.

Vegetable food.—The largest quantity of vegetable matter was eaten in December and January and formed about 12 percent of the food in each of these months. In three months—March, June, and September—no vegetable food was found in the stomachs. It is hardly probable, however, that such would always be the case in these months. What was supposed to be pulp of fruit was found in one stomach. This was the only vegetable substance noted that could possibly be useful to man. Six stomachs contained seeds more or less broken, of which only one was identified, a single seed of turkey mullen (*Eremocarpus setigerus*). In one stomach was a small gall, and in six were various substances, such as bits of dead leaves, plant stems, and rotten wood, which may properly be denominated rubbish.

Animal food.—Of the animal food various families of bugs (Hemiptera) make up the largest percentage. One of the most interesting items is the black olive scale, which was found in a number of stomachs but does not appear to be eaten extensively. The great bulk of the hemipterous food was made up of leaf-bugs, stink-bugs, shield-bugs, leaf-hoppers, tree-hoppers, and jumping plant-lice, though there were representatives of other families. The aggregate of the Hemiptera eaten is about 31 percent of the total food. It is distributed with great regularity through the year and varies less from month to month than any other food. With the exception of the olive scale no specially harmful species was identified, but bugs belonging to the same family as the notorious chinch bug were found. As a vast majority of the members of this order are injurious to vegetation their destruction by birds must be considered beneficial.

Beetles collectively amount to over 21 percent of the food. They may be placed in three groups—ladybirds, weevils, and other beetles. Ladybirds are probably the most useful insects of the whole order of Coleoptera, so that their destruction by birds is to be deplored. Bewick's wren eats them to the extent of a little more than 3 percent of the whole food. This is not a large percentage, though greater than could be wished. On the other hand, the bird eats weevils, or snout-beetles, to the extent of nearly 10 percent of its food. As all the members of this group (Rhynchophora) are practically harmful, and some of them the worst pests of the orchard and forest, it must be allowed that we are paid for our ladybirds at a fairly good price. A number of stomachs contained beetles of this group belonging to the family of engravers (Scolytidæ), which live under the bark of trees and greatly damage the timber. The stomachs of two wrens taken in Pacific Grove in the month of January contained 85 and 80 percent of these beetles.

The owners of the Pacific Grove pine forests have engaged the services of an expert to investigate the damage being done to the pines by scolytids and other insects, and, if possible, to devise a remedy. Is it not evident that the bird under consideration is one of Nature's remedies for this evil? The trouble is that there are not enough birds to wage effective war against the insects. In many cases, perhaps in this one, man himself is partly to blame for present conditions. The birds are destroyed—destruction of the forest follows. By furnishing proper facilities for breeding in the shape of bird boxes the numbers of this wren in the State of California may be greatly increased and the forest trees correspondingly protected from insects.

Other beetles, mostly leaf-beetles (Chrysomelidæ) were eaten to the extent of a little more than 8 percent. While nearly all of the leaf-beetles are theoretically harmful none of those identified in the food are especially destructive to crops.

Hymenoptera, including both ants and wasps, aggregate a little more than 17 percent of the wren's diet. They are a fairly constant constituent of the food and do not appear to vary much according to season. The greater number was found in March, but as only two stomachs were collected in this month the record is not conclusive. Ants form about 7 percent of the food. The economic relations of these insects have been discussed elsewhere. Wasps make up the rest of the item, about 10 percent, and have no especial economic significance. Caterpillars and a few moths and some cocoons constitute a little less than 12 percent of the wren's food. Contrary to what might be expected, not all these are taken in summer. The 14 stomachs obtained in February contained caterpillars to the amount of over 13 percent of their contents. They were probably found hibernating in crevices of bark. A few moths were eaten, but, as usual, they were only a small item of the food. Small cocoons of tineid moths were found in a number of stomachs.

Grasshoppers amount to 4 percent of the wren's diet. Most of them are eaten during the summer and fall, though some appeared in stomachs taken in January. While these insects are a favorite food for many birds they are probably rather large and too terrestrial in habits to be eaten in great numbers by wrens. Other insects, mostly flies and a few remains which could not be identified, make up about 6 percent of the stomachs' contents. Flies (Diptera) are eaten very irregularly and appear not to be relished. Spiders are taken to the extent of somewhat more than 5 percent of the total food. As spiders live about trees, bushes, fences, rocks, and outbuildings it is not surprising that they are captured by wrens, but the rule seems to be that while all insectivorous birds eat spiders to some extent no species eats many.

List of insects found in stomachs of Bewick wren:

COLEOPTERA.

Cercyon fulvipenne.
Hippodamia convergens.
Cocinella t. californica.
Scymnus marginicollis.
Aphodius rugifrons.
Microrhopala montana.
Diachus auratus.
Crepidodera helxines.
Epitrix parvula.
Exema conspersa.
Diabrotica soror.
Cryptocephalus castaneus.
Gastroidea sp.
Bruchus seminulum.
Blapstinus dilatatus.
Notoxus alamedæ.
Ceutorhynchus nodipennis.
Pelenomus cavifrons.
Apion sp.

HEMIPTERA.

Sinea diadema.

Saissetia oleæ.

Remains of insects belonging to the following families were found, but not further identified:

COLEOPTERA.

Carabidæ.
Hydrophilidæ.
Staphylinidæ.
Coccinellidæ.
Elateridæ.
Scarabæidæ.
Chrysomelidæ.
Bruchidæ.
Tenebrionidæ.
Anthicidæ.
Curculionidæ.
Scolytidæ.
Other Rhynchophora.

DIPTERA.

Muscidæ.
Tipulidæ.

HEMIPTERA.

Emesidæ.
Reduviidæ.
Aradidæ.
Capsidæ.
Lygæidæ.
Pentatomidæ.
Corimelænidæ.
Scutelleridæ.
Jassidæ.
Membracidæ.
Psyllidæ.
Coccidæ.

WESTERN HOUSE WREN.

(*Troglodytes aedon* subspp.)

The western house wren, like its eastern relative, is a common resident about outbuildings and other structures that offer suitable nesting sites and good foraging ground. In its general appearance and habits it is so like the Bewick wren that the casual observer is likely to confuse the two. Like other members of the family, it is largely insectivorous and rarely eats vegetable food.

Only 36 stomachs of this species from California are available for examination, but the character of the food agrees so nearly with that of the eastern form that the general results obtained from the study of that subspecies may be applied to the western bird.

Animal food.—In the 36 stomachs examined animal matter, consisting entirely of insects and spiders, formed 97.5 percent, and vegetable food 2.5 percent. Beetles, as a whole, amount to about 20 percent; caterpillars, aggregating 24 percent, are taken in the earlier months of the year; and Hemiptera, amounting to 33 percent, are eaten chiefly in the last of the season. Grasshoppers amount to about 5 percent, and different insects, mostly ants and other Hymenoptera, aggregate 15 per cent.

Vegetable food.—The vegetable matter consists of rubbish and one grass seed, probably all of it swallowed accidentally.

Among the 36 stomachs, of which the record has just been given, were 18 nestlings, some being about a week old, others about ready to leave the nest. The results of the examination of these were tabulated by themselves in order to determine the differences, if any, between the food of the adults and that of the young. No vegetable matter was found in any of the stomachs, and the animal food was distributed among a comparatively few elements. Bugs (Hemiptera) are the largest item, and amount to nearly 36 percent. Caterpillars and grasshoppers stand next, with 17 and 16 percent, respectively.

It is interesting to note that about three times as many grasshoppers are fed to the young as are eaten by the adults. Wasps and ants amount to a little more than 6 percent, and are the smallest item. Spiders appear to the extent of a little over 11 percent. Beetles, however, constitute the most interesting item of the food. They were eaten to an average extent of somewhat more than 11 percent, and were nearly all ladybirds (Coccinellidæ) contained in the stomachs of five individuals of a brood of six. The amount in each stomach varied from 15 to 65 percent of the contents, and averaged 29 percent of each of the six birds. It is a question which is the more surprising, that this brood had eaten so many coccinellids, or that the others had eaten so few. Only three other stomachs contained any of these beetles and those were all adults. The house wren does not exhibit any special proclivities for ladybirds, and it would seem probable that in this case either other food was wanting or these beetles were specially abundant.

In addition to the examination of stomachs, observations were made upon the feeding of nestling wrens. A nest situated in the porch of the house of Mr. W. O. Emerson, at Haywards, Cal., was observed for one-hour periods from soon after the young were hatched until they were nearly ready to fly. The nest was watched at various times of day, so as to include as nearly as possible all hours of daylight. During the first two periods the male aided in feeding the young, but afterwards was not seen, and the whole care of the young devolved upon the mother. The number of young probably was not fewer than six. Following are the results in tabular form:

Date.	Forenoon.		Afternoon.	
	Hour of observation.	Number of feedings.	Hour of observation.	Number of feedings.
May 18...	10.00-11.00	8	4.00-5.00	7
May 19...	9.35-10.35	13	4.30-5.30	10
May 20...	10.29-11.29	16	....	....
May 21...	8.23- 9.23	20	2.01-3.01	12
May 23...	8.22- 9.22	19	....	....
May 26...	10.35-11.35	32	....	....
May 27...	....	....	2.36-3.36	31
May 28...	8.20- 9.20	38	....	....
May 30...	10.40-11.10	28	....	....

As will be noticed, the whole time of observation covered a period of thirteen days, although the nest was not watched every day. In all the nest was watched for twelve hours, and the total number of times that food was brought to the young was 234, or an average of 19½ times per hour. The young were fed as early as 5 o'clock in the morning and as late as 7 in the evening, thus making for the parent birds a working day of fourteen hours. Only a little plain arithmetic is necessary to show very nearly the number of insects destroyed by this family in a single day.

These observations were made with watch in hand and the time of each feeding noted. In many cases the parent bird was away in search of food only half a minute. Once there was a heavy mist nearly all day, when the mother wren was hard pressed to find food for the ever-gaping mouths of her young. No flying insects were abroad, and the supply of caterpillars from the immediate vicinity had been exhausted. In this extremity the mother turned her attention to spiders and was seen to visit the interior of a summer house, also to investigate a pile of flower pots and tubs and to plunge into and under an evergreen hedge in search of something that would answer for food. As the nest was watched at very short range, it was often possible to determine the nature of the food brought by the parent. When the nestlings were very young, it consisted almost entirely of small green caterpillars, commonly called 'canker-worms.' Later this was varied by tipulid flies (daddy-long-legs), small moths, and spiders. Some of the insects brought were not determinable, probably flies and wasps.

SUMMARY.

From the above sketch of the food of the house wren it will be seen that there is practically only one item to which exception can be taken, namely, the coccinellid beetles, or ladybugs. But the record is so meager that it is not safe to draw general conclusions. It is probable that a more extensive investigation of the food of the California bird will show that it is entitled to the same high economic rank as its eastern relative.

WESTERN MARSH WREN.

(*Telmatodytes palustris* subspp.)

The marsh wren, as its name indicates, is a resident of swamps and marshy grounds. At first thought its food might not appear to be of any economic importance, but investigation shows that it does not differ from that of the orchard wrens as much as one might infer from difference of habitat. Only 53 stomachs of this species have been obtained for examination. While this number is not sufficient as a basis for final judgment, it suffices to show how closely the food of this species resembles that of its congeners.

Vegetable food.—But little vegetable food was found in the stomach of the marsh wren, and the precise value of most of that was not determinable. A few seeds of sedge and one of amaranth were all that were identified. The total amount was a trifle over 2 percent.

Animal food.—Beetles, wasps, ants, bugs, caterpillars, and a few miscellaneous insects, with some spiders and snails, make up the bill of fare. As with the Bewick and the house wren, bugs are the largest item, but do not quite equal the quantity eaten by those industrious bug-hunters. While the Bewick eats these insects to the extent of 31 percent of its food, the marsh wren eats them only to the amount of 29 percent. In this respect there seems to be little difference between the bird that gets its food from trees and the one that feeds among the tules and sedges. The families represented are those of the assassin-bugs, damsel-bugs, leaf-bugs, stink-bugs, leaf-hoppers, and tree-hoppers, most of which are usually found on trees—in fact, one is forced to the conclusion that the marsh wren must at times forage upon trees or shrubs. Scales were found in one stomach, which is another point of resemblance between the diet of this bird and that of the habitual tree inhabiters.

In the marsh wren's food caterpillars and chrysalids rank next to bugs in importance. They amount to about 17 percent of the whole, and appear in the food of every month. Cocoons of tineid moths were contained in a number of stomachs, another indication that the birds visit trees.

Beetles constitute 16 percent of the food. While a number of the commoner families are represented, the terrestrial forms are rather more prominent than in the food of the arboreal wrens. A few carabids and a number of coccinellids together make up 2 percent of the food, and were the only useful insects eaten, unless the assassin-bugs are reckoned as such. As these feed on other insects they must of course do some good. Ants and wasps amount to about 8 percent of the food, and most of them were eaten during the fall months. Flies, grasshoppers, dragon-flies, and a few insect remains not further identified make up over 11 percent of the food. They were eaten very irregularly. Spiders constitute somewhat more than 5 percent, and, as usual, are very regularly eaten, but in small numbers. Small mollusks (snails) were eaten by quite a number of birds, and 1 stomach contained 11 specimens.

SUMMARY.

This brief review of the food of the marsh wren, while not absolutely conclusive, is sufficiently near the truth to prove that the bird is to be ranked among our eminently useful species. Of some birds it has been said that their peculiar merit lies in the fact that they reside in orchards and cultivated ground and hence destroy insect pests in the very places where their mischief is done. This can not be asserted of the marsh wren, but it must be remembered that many harmful species of insects breed and live in marshes and waste places as well as in grainfields and orchards, so that the birds which destroy them on wild lands are removing the source of supply from which are recruited the hosts that infest the farm.

CACTUS WREN.

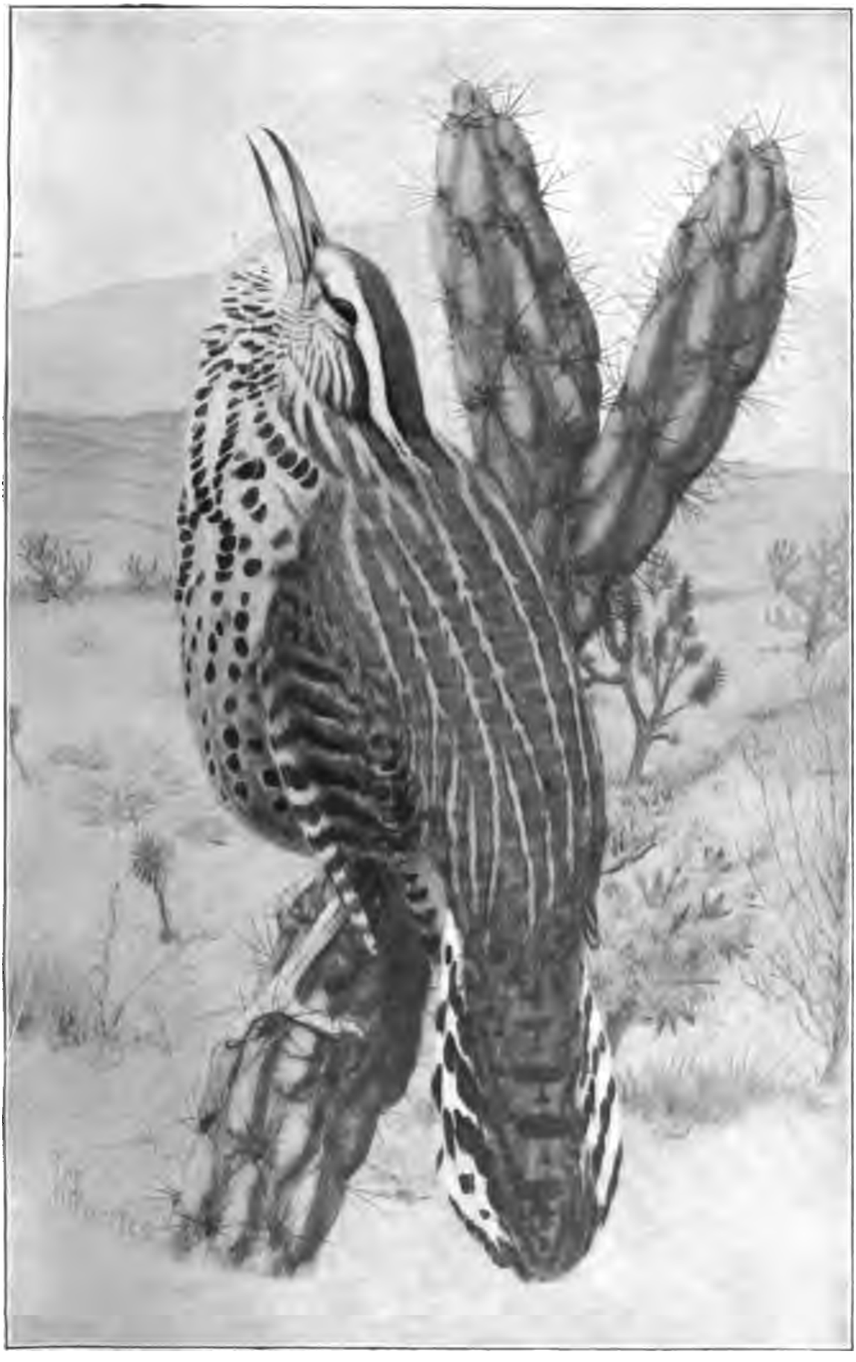
(*Heleodytes brunneicapillus.*)

(Pl. IV.)

The cactus wren is so exclusively a bird of the desert and waste places that its food may be thought to have little, if any, economic interest. It is not safe to assume, however, that the bird will never affect the interests of agriculture because it does not do so at present. Moreover, its food habits have a scientific interest which justifies a brief review. A number of the birds whose stomachs have been examined for this work were taken near orchards and grainfields, and there can be little doubt that, with the spread of cultivation, the species will adapt itself to a somewhat different environment and become of economic importance. We find, in fact, that its food is made up of practically the same orders and families of insects that compose the diet of birds living on agricultural lands, but the relative proportions differ widely, and in most cases the species are probably different.

Only 41 stomachs of the cactus wren were available for examination. They were taken in the region from Los Angeles to San Bernardino, and from July to January, inclusive. They contained about 83 percent of animal matter to 17 of vegetable.

Animal food.—Beetles and Hymenoptera, the latter ants and wasps, were the two most important items of the animal food. Each made up about 27 percent of the total. The beetles belong to several families, but weevils, or snout-beetles, were the most noticeable, and amount to somewhat more than 10 percent. One stomach contained 11 of these insects and another 10, while others held fewer. Only one species, *Rhigopsis effracta*, was identified. Five of these were in 1 stomach. The other beetles belong to more common families. Coccinellids were found in 1 stomach and carrion beetles in 2. They were the only insects noted that can be considered as useful. Hymenoptera are represented by many ants and a few wasps. These are just the insects which the cactus wren might be expected to find, for dry land and sunshine are the conditions which favor these creatures. Grasshoppers amount to a little more than 15 percent. This



CACTUS WREN (HELEODYTES BRUNNEICAPILLUS COUESI).

is the only wren that eats these insects to any considerable extent except as nestlings.

Bugs (Hemiptera) amount to only a little more than 5 percent of the food, which is the smallest quantity eaten by any of the wren family. This item, however, contains one unexpected element—that is, black scales (Saissetia). These appeared in 6 stomachs, and must have been obtained from trees or shrubs, possibly from fruit trees. In any case their destruction is a welcome service. Caterpillars and their allies (Lepidoptera) were eaten to the extent of a little more than 5 percent. Among them were many cocoons of tineid moths, indicating again that the cactus wren obtains some of its food from trees and shrubs. A few unidentifiable insects and spiders amount to somewhat more than 3 percent. This is the smallest record for spiders of any of the wren family, which is much given to eating these creatures, finding them in crannies in rocks, stumps, and other places. A few of the long bones of a tree frog were found in 1 stomach.

Vegetable food.—Seventeen percent of vegetable matter was found in the stomachs of this bird. This is the largest percentage found in the stomachs of any species of wren yet examined. The vegetable food of the cactus wren consists of fruit pulp and weed seeds. The former amounts to nearly 13 percent, but in all cases where identification was possible consisted of wild species. Of these, only 3 were fully identified—cactus (Opuntia), elderberry (Sambucus), and Cascara (Rhamnus), the last only in 1 stomach. Nothing was found to indicate that cultivated varieties had been eaten. Seeds, which amount to 4 percent, are those of the poison oak (Rhus), and a nonpoisonous species, with filaree (Erodium) and Amisinckia, most of them useless plants or worse.

SUMMARY.

From this brief inspection of the cactus wren's food it is seen that it contains but little that is useful to man, while the great bulk is made up of elements that are, or would be, harmful if present on cultivated lands. The bird thus sustains the good reputation of the rest of its family.

OTHER WRENS.

Some half a dozen stomachs each of the western winter wren (*Olbiorchilus hiemalis pacificus*) and dotted canyon wren (*Catherpes mexicanus punctulatus*) and the rock wren (*Salpinctes obsoletus*) have been examined. This number is entirely too small to serve for specific statements in regard to their food except that it may be said that it corresponds closely to that of the other species of the family discussed in foregoing pages.

From this somewhat limited investigation of the food of the California wrens several points may be regarded as established: (1) That these wrens are essentially insectivorous; (2) that an overwhelming majority of the insects composing their food are harmful species; (3) that the quantity of vegetable food eaten is so small as to have no economic importance.

CALIFORNIA CREEPER.

(*Certhia familiaris occidentalis.*)

Only 7 stomachs of the California creeper were available for examination, but they confirm the good opinion observers have formed of the habits of this bird. Like the titmice and nuthatches, the creeper is an indefatigable forager on the trunks and branches of trees, and the food it obtains there is of the same nature—that is, small beetles (many of them weevils), wasps, ants, bugs, caterpillars, and a few spiders. Of the 7 stomachs examined, only 1 contained vegetable food, and this had only 19 percent of seed, too much digested for identification.

While the creeper is not systematically classed with the nuthatches and titmice, its food habits closely ally it to these birds and to the wrens, and whatever good is true of them applies with equal force to the creeper.

NUTHATCHES AND TITMICE.

(Paridæ.)

Few families of birds contain so many absolutely harmless and thoroughly useful species as that of the nuthatches and titmice. All of the American species are small, and several are so minute that the larger species of humming birds exceed them in size. In colors they are neither brilliant nor showy, black, white, brown, and gray being the predominant tints of their plumage. In manners and voice they are equally unobtrusive, and so little do their movements attract attention that one may be surrounded by them in the forest before he is conscious of their presence. More than forty species and subspecies of the titmouse family reside within the limits of the United States, of which some fifteen live in California.

From an economic standpoint the titmice are the reverse of insignificant. They are essentially inhabitants of trees and shrubs, and obtain almost their entire living from them. Their food consists largely of small insects and their eggs and larvæ, and, as the individuals of most of the species are numerous and spend all the daylight hours searching for food, it follows that the number of harmful creatures they destroy is beyond calculation. As conservators of forest and orchards there are few birds that compare with them. The insects they destroy are largely those that feed upon the leaves, blossoms, and fruit of trees, with some that bore into the wood or burrow under the bark, thereby injuring or killing the tree itself. On the other hand, they do not prey upon fruit, grain, or other product of husbandry. The small amount of vegetable matter they eat consists principally of small galls, whose destruction is a benefit, with a few seeds and a little wild fruit.

PYGMY NUTHATCH.

(*Sitta pygmæa.*)

The nuthatches are small, inconspicuous birds that live upon trees and for the most part remain in forests or groves, though not rarely visiting the orchard. While allied to titmice they form a fairly well-defined group and can be easily distinguished from titmice proper: As gymnasts they probably lead the avian world. After watching their movements one might suppose that nature had quite exempted them from the operation of the laws of gravity, as they move up or down a tree with equal facility, or along the underside of a horizontal branch where they inspect a promising knot hole or cranny, apparently without the least idea that they are upside down. The food they obtain from trees is of the same general character as that of the rest of the titmouse family.

Unfortunately only a few stomachs of these birds are at hand for examination—enough, however, to give a general idea of the diet.

The pygmy nuthatch is the smallest of the group, but as a destroyer of noxious insects it is far from insignificant. Only 31 stomachs of this feathered midget are available for examination, but the number is sufficient to bring out some strong points of the bird's diet. The relative proportions of animal and vegetable food, as indicated by the contents of these stomachs, are approximately 83 percent of the former to 17 percent of the latter.

Animal food.—The largest item of animal food is Hymenoptera, composed mostly of wasps, with a few ants. They amount to about 38 percent of the whole. Next in order are Hemiptera, aggregating 23 percent. A large proportion of these belong to the family Cercopidæ, commonly known as spittle-insects, from the fact that they develop inside of a froth-like substance resembling saliva produced in summer upon grass and various plants and trees. While none of these insects have yet become pests, there can be no doubt that collectively they do considerable harm to plants, as sometimes they are very abundant and subsist entirely upon their sap.

In this connection peculiar interest attaches to the contents of 20 stomachs of the pygmy nuthatch from the pine woods of Pacific Grove, near Monterey, June 24 to July 13. Eighteen of these stomachs contained remains of Cercopidæ, and six were filled with them. The average for the 18 stomachs is a little more than 76 percent of all the food. They were not identified specifically, but undoubtedly are one of the several species known to feed upon the pine. Beetles of various families form about 12 percent of the food. There were many weevils, or snout-beetles, in the stomachs, and some coccinellids, which were the only useful insects found. They amount to 9.6 percent, which is the largest record for any bird yet examined, except the vireos; but as this percentage is based upon the examination of so few stomachs, it can not be considered as wholly reliable. Caterpillars amount to 8 percent, and with a few spiders (1 percent) account for the rest of the animal food.

Vegetable food.—The vegetable portion is made up almost entirely of seeds, of which a majority are those of conifers, as was to be expected from the habits of the bird.

Two other species of nuthatches, the slender-billed (*Sitta c. aculeata*) and the red-breasted (*Sitta canadensis*) occur in California. A few stomachs of each have been examined and the contents found to agree substantially with the foregoing.

SUMMARY.

In conclusion, it may be said that, like other genera of the Paridæ, nuthatches are eminently useful birds. They do not prey upon cultivated crops, eat but few useful insects, and probably are among our most efficient conservators of the forest and of the orchard.

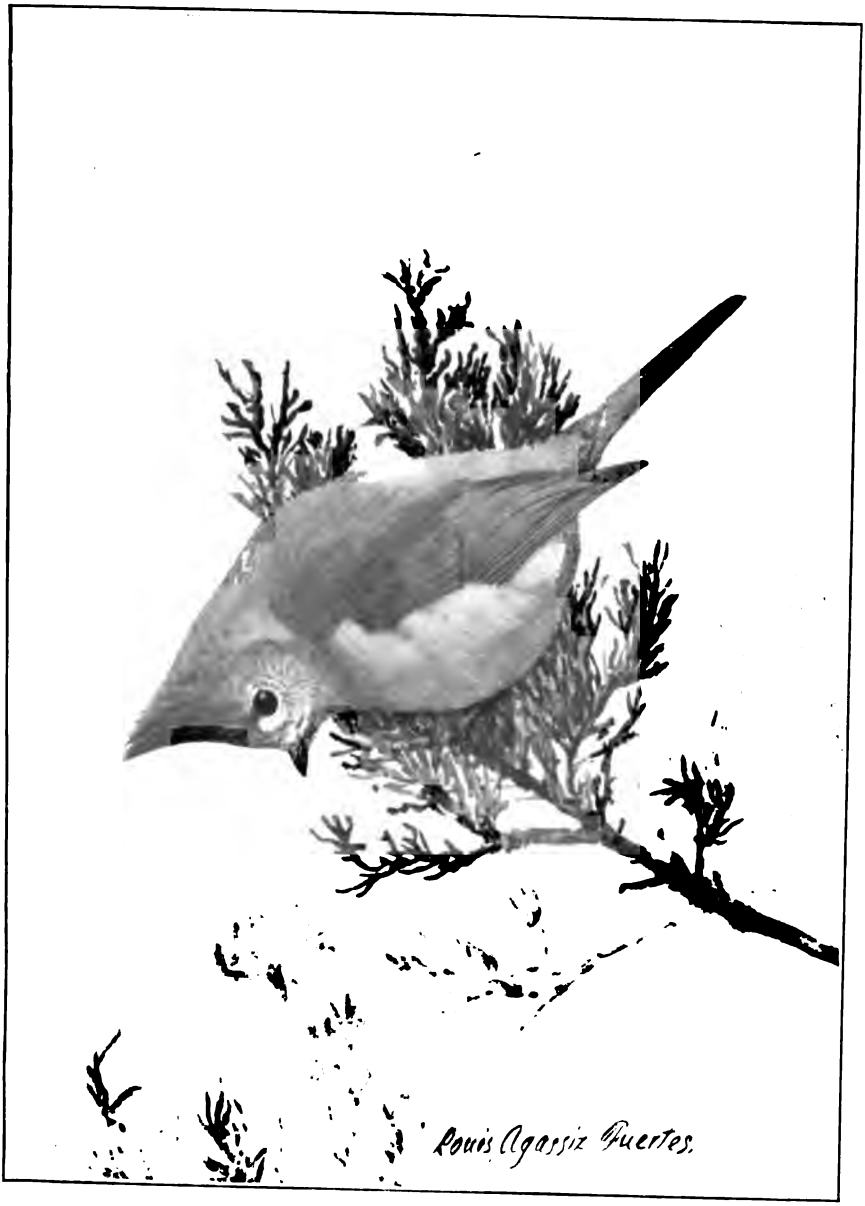
PLAIN TIT.

(*Bæolophus inornatus.*)

(Plate V.)

The plain tit, like the rest of its family, is quiet and unobtrusive, attracting little notice by its voice and movements, and probably is the most modestly dressed of them all. While it seems to prefer to hunt on oaks, it does not neglect fruit trees, and often may be seen flitting about the orchard.

The general character of its food is the same as that of other small arboreal species. The relative proportions consumed, however, differ somewhat from those taken by other members of the family. The plain tit eats a greater proportion of vegetable food than any other titmouse so far as known, and, what is more remarkable, a large part of this consists of the pulp of fruit.


Louis Agassiz Fuertes.

PLAIN TITMOUSE (BAEOLOPHUS INORNATUS).

The following brief account of the food of this bird can be considered only preliminary, as but 76 stomachs were available for examination. These, however, are distributed through the year, so that every month is represented by at least three. While these results may be modified by future investigation, they probably afford a fair general idea of the yearly food of the species.

Animal food.—Unlike most of the titmice, the plain tit eats less animal than vegetable food, the proportion being 43 percent of animal to 57 of vegetable. Examination of a greater number of stomachs may modify these figures but probably will not reverse them. The animal food is quite evenly divided among a number of elements, but, as with the bush tit, bugs (Hemiptera) appear to be the favorite, mostly eaten during the summer months. These amount to 12 percent of the food. This is a little more than one-fourth of the amount of Hemiptera eaten by the bush tit. The black olive scale is a prominent element of this part of the diet, and forms nearly 5 of the 12 percent. In the month of August nine stomachs were taken, and 34 percent of their contents consisted of these scales, while one stomach was filled with them. The plain tit probably eats this insect more or less throughout the year, but the limited number of stomachs under consideration does not warrant a positive statement. The other hemipterous food consists of representatives of several families, such as leaf-hoppers (Jassidæ), jumping plant-lice (Psyllidæ), tree-hoppers (Membracidæ), and other remains not identified.

Lepidoptera, represented mostly by caterpillars, are the next most important ingredient of the food. They amount to nearly 11 percent, and are mostly eaten during the warm months, though one stomach taken in March was filled with caterpillars and one moth.

Beetles (Coleoptera) are next in importance in the food, of which they form nearly 7 percent. All are harmful species, but the members of one family are especially interesting. The genus Balaninus is composed of weevils in which the snout attains its greatest length, and sometimes is as long as the rest of the body. The insects, by means of this long snout, bore into nuts and acorns, wherein they deposit eggs, which hatch grubs that eat the nut. The tit finds these beetles while foraging upon the oaks. One stomach contained the remains of 13 of them, another 11, a third 8, and a fourth 7, while others contained fewer. The plain tit feeds upon mast to some extent, and it is interesting to note that some of the stomachs which held remains of Balaninus contained acorn meat also, showing that the birds found the one while foraging for the other.

Hymenoptera in the shape of ants amount to nearly 4 percent, while wasps make up the total of this order to about 6 percent.

Other insects aggregate a little more than 5 percent. Tipulid flies (daddy-long-legs) were found in several stomachs, as were grasshoppers also. One stomach contained the remains of 13 of the latter, a remarkable number for so small a bird, but the bulk was not great, and they were probably the débris of several meals. Spiders are a very constant article of food, but do not appear in great numbers, as the average for the year is somewhat less than 1 percent.

Vegetable food.—In the vegetable food of the plain tit, fruit amounts to nearly 32 percent. Fruit is a rather surprising item of the food of this bird, as no one, so far as the writer can learn, has ever accused it of destroying fruit. The quantity is three times as much as is eaten by the linnet, and is another illustration of the fact that in estimating the status of a species the number of individuals as well as the amount eaten by each individual must be considered. The fruit consumed appears to be of the larger cultivated varieties, as no seeds of wild berries were found.

Cherries were identified in a number of stomachs, and pulp of the larger fruits was abundant. As considerable of this was contained in stomachs taken in the late fall and winter months, it is evident that it was refuse left on the tree and of no value. Not only does the plain tit eat fruit, but to some extent it indulges also in grain. Oats were found in a number of stomachs and constituted nearly 30 percent of the contents of two stomachs taken in January. Grain is probably not eaten to any considerable extent, however, as the amount for the year is but little over 1.5 percent, and oats was the only variety identified. Leaf galls, seeds of poison oak, weed seeds, unidentifiable matter and rubbish make up the remainder, 24 percent, of the vegetable food. None of these are of much economic importance, except that the distribution of poison-oak seed is a nuisance.

SUMMARY.

From this somewhat imperfect review of the food of the plain tit it is evident that in its present numbers it is useful. The insects it eats are practically all harmful and the scales exceedingly so. Moreover, its habit of foraging in trees enables it to capture some of the worst enemies of fruit and renders its work in this direction invaluable. On the other hand, it eats quite a large percentage of fruit, most of which appears to be of cultivated varieties, and should the bird ever become as abundant as the linnet now is it would undoubtedly be a pest. This contingency, however, is extremely unlikely.

CHESTNUT-SIDED CHICKADEE.

(*Parus rufescens* subspp.)

While this bird at present inhabits mountain regions rather than orchards, still it may not be out of place to give a short digest of our knowledge of its food. Fifty-seven stomachs were available for examination, and these were taken in every month of the year, except March, April, and May. The food consisted of nearly 65 percent of animal matter and 35 of vegetable.

Animal food.—Caterpillars constitute 18 percent of the animal portion. They were found in nearly every month in which stomachs were taken, there being a fairly good percentage even in January and December. The greatest amount, 53 percent, was eaten in August. Hemiptera, consisting of leaf-hoppers, tree-hoppers, and olive and other scales, constitute the most important item of food, and amount to about 25 percent. These were found in all except two winter months. Wasps were eaten to the extent of 13 percent of the food, but no ants were found. Beetles amount to less than 2 percent of the food, but nearly all are noxious; weevils appeared in one stomach. Flies and grasshoppers are conspicuous by their absence, and not even a trace of one was discovered. Spiders are a very constant element of the food of nearly all the titmice. In that of the chestnut-side they amount to nearly 7 percent for the year, though in August they constitute nearly 16 percent.

Vegetable food.—The vegetable portion of the food consists of fruit pulp 8 percent, seeds nearly 20 percent, and miscellaneous matter 7 percent. Fruit pulp was found only in a few stomachs taken in the fall and winter and was probably waste fruit. The seeds eaten were mostly those of coniferous trees, as was to be expected of a bird which spends so much of its life in evergreen forests. The miscellaneous items of the vegetable food are leaf galls, bits of moss, and rubbish.

SUMMARY.

The above sketch of the chestnut-sided chickadee, while very imperfect, suffices to show the general character of its food. A few stomachs also of the mountain chickadee (*Parus gambeli*) have been examined and the contents found to agree in a general way with the food of others of the group.

WREN TIT.

(*Chamaea fasciata* subspp.)

This modest, secretive bird, like the eastern chat, is more often heard than seen. At present it does not often live in orchards and gardens, and when it visits these it sticks closely to hedges and the denser parts of the shrubbery. In general it keeps to its original abiding places in the dense chaparral of canyons and hillsides. So long as it is confined chiefly to these situations its food habits will never be of more than secondary importance, but as cultivation spreads the bird will be forced more and more to reside in cultivated districts.

The number of stomachs available for examination is 165, and as they represent every month except July they afford a fair idea of the salient features of the bird's yearly food. Of this 52 percent is animal matter, insects and spiders, and 48 percent of various vegetable substances.

Animal food.—The most important item of the animal food consists of ants and wasps (Hymenoptera), which amount to 23 percent of the whole. This is in strong contrast to the bush tit, whose diet contains scarcely any of these insects. About half of the Hymenoptera are ants. This is exactly what might be expected of a bird of such terrestrial habits and one so given to lurking under bushes and about decayed logs and rubbish. The other insects of this order are small wasps. Beetles, collectively, the next most important item of food, amount to about 10 percent. The only useful species identified were a few ladybirds (Coccinellidæ), and a separate account of these was kept in order to estimate the harm done by their destruction. The result shows that the diet of the wren tit contains less than 1 percent of these useful beetles. The remaining beetles belong to various families, all of them harmful to vegetation. Caterpillars constitute a little less than 8 percent of the food, and are a very constant element of the diet. They appear to be eaten at all seasons, but in the early summer they amount to about one-fourth of the food. Quite a number of cocoons of tineid moths also were present in the food.

Bugs (Hemiptera) are eaten to the extent of about 7 percent of the animal diet. In this respect the wren tit differs from the bush tit, over 44 percent of whose food is made up of these noxious insects. In one particular, however, the two birds are alike; scales (Coccidæ) are prominent in the food of both. The black olive scale (*Saissetia oleæ*) and the greedy scale (*Aspidiotus rapax*) were identified in the stomachs of both birds, and many not specifically identified were found. The scales were probably obtained from orchards, as it is not likely that these insects have spread to wild plants and forest trees. As scales are to be had at all seasons they are a constant element of the food of tits. The remaining animal food, less than 5 percent, is composed of various insects and some spiders. One stomach contained the legs of a grasshopper and another the remains of a wood-cricket. These are the only orthopterous remains in any stomach. Flies (Diptera) were eaten very sparingly. Spiders appeared in a great many stomachs but not in large numbers. They amount to a little less than 2 percent of the food. In one stomach were found 26 mites, commonly parasitic on beetles and other insects. Their hosts had probably been eaten by the tit.

Vegetable food.—The vegetable contingent of the food, 48 percent, is made up of various substances, but may be arranged in three categories—fruit, poison-oak seeds, and other vegetable matter. Fruit, identified by seeds, pulp, and skins, amounts to a little more than 20 percent of the whole food. Few direct complaints, however, have been lodged against the wren tit on the score of damaging fruit, and yet this record is nearly twice that of the linnet—the bird against which the heaviest charges are made by the orchardist. The reason for this difference is probably not far to seek. There are undoubtedly a hundred linnets in California to one wren tit. This again illustrates the point before made, that the mischief done by birds usually results from a superabundance of the individuals of a particular species, all uniting simultaneously to attack some particular product. Moreover, the fruit consumed by the wren tit consists largely of wild varieties—such as elder berries (Sambucus), snow berries (Symphoricarpos), coffee berries (Rhamnus), twinberries (*Lonicera involucrata*), and others of a similar character. Seeds of blackberries or raspberries (Rubus) were found in a few stomachs, but these may have been either wild or cultivated.

As the seeds of poison oak (*Rhus diversiloba*) occurred in many stomachs a separate account of them was kept. From August to February, inclusive, they form a constant and important element of the diet. For these seven months they constitute more than one-fourth of the food, and the average for the year is over 16 percent. It seems natural enough that the wren tit should eat these seeds, as they are abundant and easily accessible. The fact is to be deplored, however, as they are not destroyed in the stomach, but either pass through or are regurgitated in condition to germinate. The seeds apparently are eaten for the sake of the rather thin layer of dry white pulp that surrounds them. No doubt this is very nutritious, as in winter poison-oak seeds are a common article of diet for many species of birds. The rest of the vegetable food, over 11 percent, is made up of a few weed seeds, leaf galls, and rubbish. None of it has special economic significance.

FOOD OF YOUNG.

Among the stomachs examined were those of a brood of 5 nestlings about two weeks old, and therefore nearly ready to leave the nest. The results are of interest as showing that the wren tit follows the usual rule and feeds its young entirely on animal food. The largest item is caterpillars, which amount to 63 percent of the contents. Spiders, with their cocoons and eggs, are next in importance, with 15.6 percent. Bugs, mostly leaf-hoppers, form 12.2 percent. Beetles of the May-beetle family, with a trace of eggshell, make up the remainder, 9.2 percent. One can not fail to notice the soft nature of most of this food provided for the young. The beetles are the only exception, and these were the smallest item.

SUMMARY.

In summing up it is evident that so far as its natural food is concerned the wren tit does little or no harm, as coccinellid beetles, the only really useful insects it eats, are consumed very sparingly. Its vegetable diet presents two points for criticism. It eats a moderate amount of fruit, and were the bird as abundant as the linnet the harm it would do in orchards would perhaps more than counterbalance the good. The wren tit, however, naturally is a denizen of dense shrubbery, and as this is cleared away for farms and orchards the species is likely to diminish in numbers rather than increase, unless its habits radically change. The consumption of the seeds of poison oak is an unfortunate habit, since it aids in the dissemination of this poisonous plant, already too common and widespread. All things considered, the wren tit for the present is to be classed as beneficial.

CALIFORNIA BUSH TIT.

(*Psaltriparus minimus californicus.*)

(Frontispiece.)

The bush tit is one of the smallest species of the family, and although its name implies that it is partial to bushes, it more often is seen in large oaks and frequently on the tops of the highest trees. It shows the same indifference to the presence of man as the rest of the family, and frequently may be observed scrambling over orchard trees in search of its favorite food and paying no attention to the observer. That it does not prey upon fruit to an appreciable degree appears from the fact that less than 1 percent of its food for the year consists of fruit. Insects that live on trees, however, constitute four-fifths of its food, and most of these are harmful.

In the investigation of the food of this bird 353 stomachs were examined. They were collected in every month of the year, although April is represented by but a single one and March by only six. The greater number were taken during the growing months, when fruit and grain abound, and the fact that in these months the bird ate almost none of these products speaks volumes in its favor. The first analysis of the food of the year gives nearly 81 percent animal matter, composed entirely of insects and spiders, to 19 percent of vegetable. As the bush tit inhabits the same range during the year, monthly variations in the kind and proportions of food are only such as seasonal changes necessitate, and as these do not largely affect insects, which constitute the great bulk of the bush tit's food, it follows that the variation in diet from one month to another is not great. The smallest quantity of animal food was in March, when it amounted to 53 percent, but the percentage was almost exactly the same for November. One stomach taken in April contained nothing but insects and spiders, and 11 collected in June contained no vegetable food. Probably examination of a greater number collected in these months would result differently. While the material available for the present investigation is not so extensive as could be desired, it is sufficient to indicate beyond reasonable doubt that the relative proportions of animal and vegetable food in the diet of the bush tit vary little from season to season.

Animal food.—The largest item in the insect portion of this bird's food consists of bugs (Hemiptera), which amount to over 44 percent of the whole. The gnatcatchers are the only birds yet investigated whose diet is made up so largely of this order of insects. Moreover, the particular families of Hemiptera so extensively eaten by the bush tit are the two that are most destructive to the interests of horticulture—namely, the plant-lice (Aphididæ), and bark-lice, or scales (Coccidæ). The last amounts to nearly 19 percent of the year's food, and are eaten in every month. The greater number are consumed in July, 46 percent; June follows second in rank, when they constitute 33 percent of the food of that month. The large black olive scale (*Saissetia oleæ*) was identified in 44 stomachs, but other species also were found. The question is often asked, Does any bird feed upon the San Jose scale? While the writer is not prepared to give a positive affirmative answer from direct evidence, there can be no reasonable doubt that this insect is often eaten by birds. It must be borne in mind, however, that the so-called San Jose scale is one of the smaller species, and its distinctive characters are so minute that after it has been taken into a bird's stomach, mixed with other food, and more or less digested, it is impossible to determine its identity. It is easy to ascertain that a pasty mass in a bird's stomach is composed of scales partly digested, but to identify the species is quite another matter. The olive scale and others of its genus, on the other hand, are so large and their shells are of such structure that they can often be identified, at least generically, even from fragments.

While the San Jose scale was not positively determined, another species of the same genus, the greedy scale (*Aspidiotus rapax*), was found in 4 stomachs, and scales not specifically identified were found in 113. Of a total of 353 stomachs, 158 held scales; several were entirely filled with them, and in quite a number upwards of 90 percent of their contents consisted of these insects. No other family of insects was identified in so many stomachs. As it is certain that the food contained in a bird's stomach at a given time is only a fraction of the daily consumption, we may infer that not many days pass in the life of a bush tit when it does not eat a considerable number of scales.

Before leaving the subject it may be well to add a few words on the economic relations of scale-insects in order that the value of the work done by the bush tit may be fully appreciated. Mr. Marlatt says:

> The most destructive insect enemies of fruits in California are undoubtedly the scale insects, few if any other insects, aside from the grape Phylloxera, at all approaching them in this respect. Of these, the ones of greatest moment and in the control of which vast sums of money are expended are the black scale, the red scale, and the San Jose scale. For the olive and citrus plants the black scale is the most important, and for the deciduous plants the San Jose scale takes similar rank.[a]

When the immense number of bush tits and other birds in California that eat scale insects is considered, it becomes evident that the aggregate of these pests annually destroyed by them must be enormous. It may be urged that despite the attacks of birds, scales have caused, and still are causing, much damage to fruit trees, and that the work of birds alone is inadequate to save the trees from destruction. This is undoubtedly true, but it must be remembered that the birds are confronted with abnormal conditions. The great and rapid development of the fruit-growing industry on the Pacific coast and the simultaneous and widespread introduction of several new species of scales resulted in a sudden increase of these pests, while their enemies, the birds, enjoyed no such opportunities for increase. In time, no doubt, an equilibrium would have been reached, and birds would have played an important part in establishing this by exerting a constant and steady check upon the increase of scales. Unaided, however, their numbers are too few to cope with the insects which, under favorable conditions of climate and environment and unmolested by other natural insect enemies, multiply to countless myriads.

The remaining portion of the hemipterous food of the bush tit, over 31 per cent, is made up of plant-lice, tree-hoppers (Membracidæ). leaf-hoppers (Jassidæ), some jumping plant-lice (Psyllidæ), and a considerable number of false chinch bugs (*Nysius angustatus*), with a few lace-bugs (Tingitidæ). Of the plant-lice little need be said. As pests to vegetation their reputation is world-wide. No part of a plant is free from attack. They infest leaves, trunk, and roots, and some of their legions of species prey upon nearly every kind of land plant. They are a frequent element of the food of the tit, but as their bodies are of the softest texture specific identification is not possible. Many of them, however, were determined to be of the species commonly called 'woolly aphides,' as their bodies are covered with a white cottony or woolly substance. Aphides were identified in 30 stomachs, but it is probable that they were contained in more, as a pasty mass that could only be called 'hemipterous remains' was of frequent occurrence. Leaf-hoppers were found in many stomachs, and appear to be favorite food. Tree-hoppers also are eaten to a considerable extent, and as their bodies are hard, like those of beetles, they are more easily recognized than plant-lice. The jumping plant-lice were found in a few stomachs, but were rather difficult to distinguish in the conglomeration of plant-lice and other soft-bodied insects. False chinch bugs were found in a number of stomachs from the southern part of the State. These, perhaps, were the best preserved of any of the insects, for in most cases they could be distinguished individually. Over 50 were taken from one stomach.

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[a] Insect control in California, by C. L. Marlatt, U. S. Dept. of Agriculture, Yearbook, 1896, p. 220.

Next to the bug family, the favorite food of the bush tits seems to be beetles. They constitute somewhat over 10 percent of the year's food and attain their maximum in September, when they amount to a little more than 27 percent of the food. The fewest were taken in December—less than 1 percent—but in all the other months they were found to a moderate extent except in the one stomach taken in April, which contained none. Among them were species of the ladybug family (Coccinellidæ), which are useful insects, as they are mostly carnivorous and feed largely upon plant-lice. In order to ascertain just how much harm the tit does in devouring ladybugs, a separate account was kept, and it was found that the total amount eaten during the year was 2.4 percent of the whole food. Most of these insects were eaten in September and October, when the consumption amounted to 11 and 6 percent, respectively. These are the only decidedly useful insects eaten by the bush tit, and in view of their small number the subject may be dismissed without further comment. The other beetles taken were largely small leaf-beetles (Chrysomelidæ), all of which are harmful. With them were some small weevils (Rhynchophora), which feed upon seeds and other parts of plants, with a few scolytids that burrow under the bark of trees to their great injury.

Butterflies and moths (Lepidoptera), most of them in the larval form (caterpillars), are next to beetles in importance in the food of the bush tit. They are, however, far from being such favorite food as bugs. The total is a little more than 16 percent. They are fairly evenly distributed through the year, though in spring and early summer they are consumed to a somewhat larger extent than in fall and winter. The greatest consumption was in May, when they aggregated nearly 69 percent. Lepidoptera in the adult form do not as a rule constitute an important part of the diet of birds, but, with the exception of the flycatchers, the titmice perhaps eat the most. The greater number consumed by these insects, however, are eaten as larvæ—caterpillars. A few, however, are eaten in the pupa state, and here the bush tit has a good record. In a number of stomachs were remains of the pupæ of the codling moth, one of the worst pests to the apple industry. This insect is protected from the attacks of birds by its peculiar mode of life. It passes the larval stage inside the apple. The adult moth flies mostly by night and hides during the day. When the larva is full grown it leaves the apple and seeks a place of concealment, such as a crevice in the bark of the tree, a crack in the trunk, or among rubbish on the ground, where it changes to a chrysalis. It is in this stage that the insect is most vulnerable to the attacks of birds, and as the whole family of titmice get most of their food by searching in just such places as those used for concealment by the larva, it is not surprising that they find and devour many of them.

The cocoons of certain tineid moths are a very constant, though not large, component of the food of the bush tit. The larvæ of many of the Tineina are leaf-miners, and therefore injurious when attacking economic plants.

Strangely enough, wasps and ants (Hymenoptera) are nearly absent from the food of this bird. The total amount for the year is less than 1½ percent. In view of the fact that ants are always crawling over the trunks and branches of trees, the very places where the tits feed, it seems strange that so few of them are eaten. Moreover, plant-lice always have ants in attendance upon them, and when tits eat so many plant-lice it is rather remarkable that they should not take some of the ants also, as do the smaller woodpeckers, whose food habits are in many respects so similar. In 353 stomachs only two ants were identified, one in the adult and one in the pupal stage, and these were in separate stomachs. In 17 other stomachs a few fragments of what probably were small wasps were found, which make up the total of the hymenopterous diet of the bush tit.

The remaining animal food of this bird, about 8 percent, is composed of various insects, such as a few flies, a few bits of grasshoppers, insects' eggs not further identified, with a considerable number of spiders. That the tits should not eat grasshoppers is not surprising, as these insects do not commonly infest trees where the birds feed, and as a rule they are rather large game for such small birds. The great bulk of the 8 percent, however, consists of spiders, which constitute a constant item of food in every month. Quite a number of pseudoscorpions also were found in the stomachs, but, owing to their minute size, the percentage is not very noticeable.

Vegetable food.—The vegetable food of the bush tit may be considered under two categories—fruit and miscellaneous matter. Fruit in some form was found in stomachs taken in the months from August to November, inclusive. The average amount eaten in those four months was a little less than 1 percent. It is represented in the stomachs by pulp and skins, which have not been further identified. The miscellaneous vegetable matter is composed of a few seeds, granules of poison oak (*Rhus diversiloba*), leaf galls, and rubbish. The seeds of poison oak are eaten by many birds, and so are distributed about the country, but, as a rule, they are too large to be swallowed by the tit, which contents itself with pecking off the wax surrounding the seed. This is identified in the stomachs by certain woody granules. A large portion of the vegetable food consists of small galls, apparently from leaves. They are eaten when first developed, when young and tender. As each of these probably contained an egg or grub, it is questionable if they should not be classed as animal food. The remainder of the vegetable matter is of such a nature that the only term which really describes it is 'rubbish.' It is probable that it is mostly taken accidentally along with other food, and perhaps should not be considered in the food category.

FOOD OF NESTLINGS.

Among the 353 stomachs of the bush tits whose food has been discussed was one brood of eight nestlings about ten days old. As these are the only nestlings collected, their food would merit attention, but examination shows it to be of unusual interest. The vegetable matter in these stomachs was only three-fourths of 1 percent and consisted of one seed and some rubbish. The animal matter comprised, approximately: Beetles 2, wasps 2, bugs 8, caterpillars and pupæ 80, and spiders 7 percent. The point of greatest interest, however, lies in the fact that every one of these stomachs contained pupæ of the codling moth, distributed as follows: Two stomachs contained 2 each, two contained 3 each, one contained 4, one 7, one 9, and one 11, making 41 in all, or an average of over 5 to each. The oak tree in which these birds were found was in a belt of timber along a creek, and just across the stream was a considerable area of neglected orchard. It is evident that the parent birds used this orchard as a foraging ground and did their best toward remedying the neglect of the owner. As with nestling birds feeding and digestion are almost continuous during the hours of daylight it follows that the above record would be several times repeated during a day's feeding. There were probably not less than a dozen nests of the bush tit (several were seen) along the border of this orchard, and if, as is probable, the occupants all did as good work as the ones recorded it is evident that the birds must exert a powerful restrictive influence upon the increase of the codling moth, as well as other insects.

SUMMARY.

In a résumé of the food of the bush tit the most prominent points to be considered are the fact that four-fifths of its diet consists of insects and spiders, nearly all of which are harmful; that more than half of its animal food is limited to a single order of insects, Hemiptera; that it eats the particular families of this order which contain the worst of insect pests; that the vegetable contingent of the food is made up almost entirely of substances of no economic value. It is doubtful if more efficient checks upon the increase of many species of forest and orchard insects can be found than the titmice and other closely related species. Bush tits, therefore, are a valuable asset to the State of California and should be protected and encouraged in every possible way.

Following is a list of insects identified in the stomachs of bush tits:

COLEOPTERA.

Crepidodera helxines.
Diachus auratus.
Orthoperus sp.
Corticaria scissus.
Scymnus marginicollis.
Scymnus pallens.
Scymnus nanus.
Notoxus alamedæ.
Anthicus sp.
Apion vespertinum.
Deporaus glastinus.

HEMIPTERA.

Nysius angustatus.
Geocoris bullatus.
Saissetia oleæ.
Aspidiotus rapax.

LEPIDOPTERA.

Carpocapsa pomonella.

The following families of Hemiptera were identified:

Tingitidæ.
Capsidæ.
Membracidæ.
Jassidæ.
Psyllidæ.
Coccidæ.
Aphididæ.

KINGLETS.

Kinglets, like gnatcatchers and titmice, are small, active birds and spend most of their lives on trees. So nearly do the feeding habits of these diminutive arboreal species resemble each other that in winter it is not unusual to see companies of titmice, kinglets, creepers, and nuthatches all together, engaged in the same unending search for food. When one notices how thoroughly each tree is inspected by dozens of pairs of keen, prying eyes, he is surprised that any insects or their eggs should survive to produce broods.

RUBY-CROWNED KINGLET.

(*Regulus calendula.*)

The ruby-crowned kinglet is known in California principally as a winter resident, though in some of the high mountains it remains through the summer and breeds. Its small size would prevent it from doing appreciable injury to fruit or grain were any to be had when it is in the fruit and grain raising regions.

As might be inferred from field observations, its diet consists almost entirely of insects and their eggs, and the number it destroys is beyond computation.

In investigating the food of the kinglet 294 stomachs were examined, all taken in California from September to April, inclusive. Only 1 stomach was collected in September, 5 in March, and 5 in April. The other included months are fairly well represented. The food consisted of 94 percent of animal matter and 6 percent of vegetable. It was made up of insects, spiders, and pseudoscorpions—minute creatures resembling microscopic lobsters—fruit, weed seeds, etc.

Animal food.—The animal food is quite evenly distributed through the season. The greatest amount, 100 percent, appeared in the first and last two months, and the least, 79 percent, in January. Hymenoptera, in the shape of wasps, and a few ants appear to be the favorite food, as they aggregate over 32 percent of the whole. The stomach taken in September contained none of them, but in every other month they are fairly well represented, and with but little variation until March, when there is a sudden increase, which continues in April. This is undoubtedly due to the increased numbers of these insects following the return of warm, dry weather, for the order is noted for its fondness for warmth and sunshine. Adverse criticism may be made upon this element of the kinglet's diet, as flying Hymenoptera are useful agents in the fertilization of flowers, and some species of plants are dependent upon them for the performance of this important function. The parasitic species of this order also were found to some extent in the food of the kinglet, and unquestionably many of these are decidedly useful.

In the food of the kinglet, bugs (Hemiptera) are next in importance. They constitute nearly 26 percent of the diet, and are found in greatest quantity in the first months of the bird's winter stay, in September and October, but gradually decrease till spring.

The following families of Hemiptera were recognized in the stomach contents: Assassin-bugs (Reduviidæ), lace-bugs (Tingitidæ), leaf-bugs (Capsidæ), leaf-hoppers (Jassidæ), tree-hoppers (Membracidæ), jumping plant-lice (Psyllidæ), plant-lice (Aphididæ), and scale-insects (Coccidæ). Stink-bugs (Pentatomidæ), which are the most universally eaten by birds of any Hemiptera, are entirely wanting. Evidently it was not lack of opportunity that prevented the kinglets from eating the last-named insects, for other birds collected at the same time and place had partaken of them freely. From the human point of view it is not strange that birds should reject them, for to us their odor is vile and their taste nauseous. It will be noticed that the Hemiptera selected by the kinglet are mostly species of small size, but happily they are the very ones that are the most harmful to the interests of man. The tree-hoppers, the leaf-hoppers, and the jumping plant-lice, when abundant, are pests, and often do great harm to trees and smaller plants, while the plant-lice and scale-insects are the worst scourges of the fruit grower—in fact, the prevalence of the latter has almost risen to the magnitude of a national peril. As has been before pointed out, it is these small and seemingly insignificant birds that most successfully attack and hold in check these insidious foes of horticulture.

Beetles of various families and species were eaten by the kinglet to the extent of 13 percent of the season's food. They belong to species that are more or less harmful, with the exception of a number of ladybirds (Coccinellidæ), which from their habit of feeding on plant-lice are eminently useful. The damage done by the destruction of these useful beetles, however, is small, since they aggregate less than 2 percent of the whole food. Singularly, nearly all were in stomachs obtained in February. In this month 8 percent of these beetles were eaten, while in no other month was so much as 2 percent taken. Another curious fact is that almost all of these belong to the genus Scymnus, which is made up of minute black creatures which one might think would pass unnoticed by birds. On the contrary, the small and insignificant individuals of this genus appear to be eaten much oftener than the larger and more showy species. While the eating of ladybugs by kinglets or other birds is to be deplored, it must be acknowledged that little harm is done so long as the numbers destroyed are as moderate as the above figures imply.

Of the harmful beetles eaten the weevils are perhaps the most interesting. One stomach contained 20 individuals, which seems a large meal in view of the size of the bird. Many of the weevils belong to the family of engravers (Scolytidæ), which live under the bark of trees and are forest pests. Another beetle found in many stomachs is *Notoxus alamedæ*, an insect that lives on trees, but which does no harm so far as known. One stomach contained the remains of

100 individuals of this species. Other beetles were found belonging to about a dozen families, all more or less injurious.

Lepidoptera, both larvæ (caterpillars) and adult forms (moths and butterflies) constitute only a small portion of the kinglet's diet. They were eaten sparingly in every month but one, but in all aggregate only 3 percent of the whole. While a few caterpillars were eaten, most of the lepidopterous food consisted of the minute cocoons of tineid moths, a family of immense size, wide distribution, and destructive habits. They are largely leaf-miners, and do much damage to the foliage of fruit and other trees. They are so small that even the little kinglet can eat a great many of them at a meal. In only 2 stomachs was anything found that resembled a grasshopper, and in both the quantity was small and the identification doubtful. Flies (Diptera) constitute nearly 17 percent of the diet, but are very unevenly distributed. The greatest amount in one month was in January, 35 percent, all of which was in 7 stomachs collected in the same place within three days. These 7 stomachs contained an average of 96 percent of dipterous remains. The birds evidently found a gathering of flies, probably dormant, and filled themselves almost exclusively with them. Another series of 4, taken at the same place in February, also had eaten flies to the extent of over 80 percent of the food. Spiders and pseudoscorpions amount to nearly 2 percent of the food, and are taken quite regularly through the season, though the greater number were eaten in October. These last are curious minute creatures, the various species of which live under stones, on the bark of trees, and in old books.

Vegetable food.—The vegetable food of the kinglets may be discussed under three heads—fruit, weed seeds, and miscellaneous vegetable matter. Fruit amounts to less than 1 percent of the food, principally elderberries (Sambucus). Weed seeds are present to the extent of a little more than one-tenth of 1 percent, and may therefore be dismissed without further comment. In the miscellaneous vegetable food two items include nearly the whole—seeds of poison oak and leaf galls—which together amount to somewhat more than 4 percent. The eating of the seeds of poison oak is not a commendable habit in any bird, for the seeds are not destroyed, but after the wax on the outside is digested are either passed through the intestine or disgorged, and so these harmful plants are disseminated. In many of the stomachs certain small round bodies were found that were diagnosed as 'leaf galls.' They appear to be galls in the early stage and are eaten while small and tender.

SUMMARY.

The foregoing discussion of the food of the ruby-crowned kinglet serves to confirm popular opinion with regard to this bird. As its food consists so largely of insects and as these include so small a percentage of useful kinds, the kinglet must be classed as one of the most beneficial of birds. To the horticulturist it is especially valuable, as nearly all of its food is obtained from trees. With respect to the persistency with which it forages among trees, it differs conspicuously from such aboreal species as leave the trees in midsummer to feed upon grasshoppers.

WESTERN GOLDEN-CROWN KINGLET.

(*Regulus satrapa olivaceus.*)

Another kinglet, the western golden-crown, occurs sparingly in winter in some parts of California. Only 9 stomachs have been examined, but these in the nature of their contents are so similar to those of the ruby-crown that statements applicable to the latter are almost certain to apply as well to this species. No vegetable matter was found in any of the 9 stomachs, and the insects belong to the same orders and were taken in essentially the same proportions as by the other species.

Following is a list of beetles which were identified in the stomachs of the two kinglets:

Coccinella t. californica.
Adalia frigida.
Scymnus pallens.
Scymnus nebulosus.
Hesperobænus abbreviatus.
Corticaria ferruginea.
Throscus sericeus.
Listrus interruptus.
Aphodius rugifrons.
Diachus auratus.
Crepidodera helxines.
Epitrix parvula.
Notoxus alamedæ.
Anthicus nitidulus.
Apion vespertinum.
Pityophthorus pubipennis.

Beetles were identified as belonging to the following families:

Staphylinidæ.
Coccinellidæ.
Monotomidæ.
Lathridiidæ.
Elateridæ.
Throscidæ.
Lampyridæ.
Malachiidæ.
Scarabæidæ.
Chrysomelidæ.
Tenebrionidæ.
Anthicidæ.
Curculionidæ.
Scolytidæ.
Other Rhynchophora.

GNATCATCHERS.

(*Polioptila* spp.)

Gnatcatchers are small, active birds of modest colors and unobtrusive notes. While not conspicuous, they are none the less deserving of respect and consideration. No complaints have been made that these busy creatures ever injure fruit or other crops. Their food is composed almost exclusively of insects, which they hunt with untiring energy from morning till night. Like the titmice and kinglets, gnatcatchers are fitted by nature to perform a service which larger species are unable to accomplish. There are hosts of minute insects, individually insignificant but collectively a pest, that are too small to be attacked by ordinary birds and are to be combated by man, if at all, only at great expense. It is to so deal with such pests that they may not unduly increase that these tiny birds would seem to be especially designed. Three species of gnatcatchers live within the limits of the State of California. Two of them, *Polioptila plumbea* and *P. californica*, are confined to the southern part, while the third, *P. cærulea obscura*, occurs locally throughout the State. The material for a thorough discussion of the food of these birds is unfortunately not at hand, but there is enough to show conclusively the nature of the work they are doing, and to enable us to assign them their proper rank among the friends and helpers of mankind.

The food of the gnatcatchers is remarkably constant in character throughout the year, varying but little from month to month. It is probable that these birds have a preference for a certain diet, and search till they find it.

Only 30 stomachs of *P. c. obscura* and the same number of *P. californica* have been examined, and their contents were so similar that they may be treated as from a single species.

Vegetable food.—Of the 60 stomachs three only contained any vegetable food whatever, and in only one did it amount to a respectable percentage. This one held 92 percent of seeds of some species of Rhus; another contained 8 percent of unknown seeds, and the third a few bits of rubbish, which amounted to only 2 percent of the whole contents. The total vegetable matter in the 60 stomachs aggregated less than 2 percent of the entire food.

Animal food.—The remainder of the food, over 98 percent, is made up of beetles, wasps, bugs, and caterpillars, with a few flies, grasshoppers, and spiders. Bugs (Hemiptera) constitute more than half of the whole food, 64 percent. These belong to the families of stinkbugs (Pentatomidæ), shield-bugs (Scutelleridæ), tree-hoppers (Membracidæ), leaf-hoppers (Jassidæ), and leaf-bugs (Capsidæ), with perhaps traces of several others. In one stomach were 20 percent of black olive scales (*Saissetia oleæ*). All of these are harmful to trees and other plants. Wasps and a few ants (Hymenoptera) are next in importance as an element of the gnatcatcher's food, and amount to over 16 percent of the whole. These birds, like the flycatchers, take much of their prey on the wing, and it is probable that wasps and small bees are captured in this way. Beetles of several families were eaten to the extent of over 7 percent of the food, but no decided preference for any particular kind is indicated. The only decidedly useful insects in any of the stomachs were 2 ladybird beetles (*Coccinella t. californica*), which had been eaten by *P. californica.* As this beetle is very abundant in California it is not surprising that birds should eat a few of them. Caterpillars amount to about 5 percent of the diet of the gnatcatchers. Apparently they are not a favorite food. Other insects, such as a few flies and grasshoppers, with some spiders, aggregate 6 percent, and probably are makeshifts, eaten when nothing more palatable is at hand.

SUMMARY.

While the foregoing discussion of the food of the gnatcatchers is based upon a small amount of material, the agreement of the evidence renders it probable that a much larger quantity would not greatly change the results. This evidence confirms what has long been suspected, that the gnatcatchers are doing a useful work and should be carefully protected.

RUSSET-BACK THRUSH.

(*Hylocichla ustulata.*)

The russet-back thrush abounds in the region about San Francisco Bay and other parts of the humid coast belt. It remains in this part of the State from April to November, inclusive, and then moves farther south for the winter. Its favorite haunts are the bushes and trees bordering streams, and in these it nests and rears its young.

While the thrush is very fond of fruit its partiality for banks of streams keeps it from frequenting orchards when they are far from water. It is most troublesome during the cherry season, at the time when the young are in the nest. It might be inferred from this that the nestlings are fed on fruit, but such is not the case to any noticeable extent. The parent birds eat the fruit themselves, while the young, as is usual with nestlings, are fed mostly upon insects. The old birds eat some fruit throughout the season, but do not seem to attract much attention by their depredations on prunes and the later fruits. As the thrush, unlike the linnet, is one of the so-called 'soft-billed' birds, its attacks on fruit are limited to the thin-skinned varieties. Probably it can peck holes in ripe cherries; still it is as often seen on the ground pecking at fallen fruit as attacking the fruit on the trees. It thus probably confines its depredations upon the later fruits to such as have already been broken into by linnets or other stout-billed birds.

Be this as it may, the thrush is an efficient destroyer of insects, and during the eight months of its sojourn in the fruit region a little more than half of its food consists of harmful insects. In the investigation of this bird's diet 157 stomachs were examined. The birds came from various points about San Francisco Bay, and on the coast from Monterey to Santa Cruz, except one migrant which was taken in the southern part of the State. Only 6 stomachs were collected in April, 5 in October, and 7 in November. In the remaining four months 139 were taken, and as they are fairly evenly distributed the results for these months may be looked upon as reasonably reliable. Examination of the food shows 52 percent of animal matter to 48 percent of vegetable.

Animal food.—The greatest quantity of animal food was eaten in the first and last parts of the season—in fact, the six stomachs collected in April contained no trace of vegetable food. The animal matter decreases in each month up to September, in which month only 17 percent was eaten. From this month it increases, and ends with 62 percent in November. Too much reliance should not be placed upon the latter figures, as they were obtained from entirely too few stomachs, and are likely to be modified by the examination of more material. The animal portion of the food is mostly insects and spiders, with some earthworms and sowbugs (Oniscus).

Useful beetles (Carabidæ, Coccinellidæ, etc.) amount to less than 3 percent of the food of the year. Most of them are eaten at the beginning of the season before other insects are common. Other beetles, all more or less harmful, constitute 11 percent of the year's food, and are eaten chiefly the first of the season, decreasing toward fall but with a slight increase at the end. They are pretty evenly distributed among the more common families, and no decided preference is evident for any. It is probable that the thrush eats any beetles that come in its way, and does not make special effort to find a particular kind.

Caterpillars form somewhat more than 8 percent of the food, and while they are eaten in every month of the thrush's stay, they are taken much more freely previous to August. During and after that month they cease to be an important element of the diet. The average consumption of the first four months of the season is a trifle over 15 percent. Ants and wasps (Hymenoptera), bugs (Hemiptera), flies (Diptera), and grasshoppers (Orthoptera) are eaten by the thrush, although little preference is shown for any one of these except for Hymenoptera in the shape of ants. These are eaten with remarkable regularity throughout the season, and form about 16 percent of the food. This is the largest insect element in the food of the thrush, and the regularity with which ants are eaten would seem to indicate that they are highly esteemed and especially sought for.

While these insects do not often make themselves pests by directly attacking fruits and crops, they aid and abet the work of other insects in a way which renders them as bad as the worst of those directly attacking crops. Their habit of caring for and protecting plant-lice is too well known to require extended comment. They take possession also of the empty burrows of wood-boring larvæ and extend these galleries still farther into sound timber. They often throw up mounds on lawns and in gardens, where it is almost impossible to exterminate them. In houses they frequently are an intolerable nuisance, infesting the pantry and spoiling food. The species that are not offensive in these various ways are mostly of a neutral character in their economic relations, and their destruction by birds does neither good nor harm.

Hymenoptera, other than ants (mostly wasps), bugs, flies, and grasshoppers, with some spiders, amount altogether to 12 percent of the year's food, and appear very regularly through the season. Grasshoppers, however, are near being conspicuous by their absence, as remains were found in only 4 of the 157 stomachs. This is rather remarkable for a bird whose habits are so terrestrial as those of the thrush. The majority of ground-feeding birds and many arboreal species feed largely upon grasshoppers. In fact, there is no order of insects for which insectivorous birds in general show such a decided preference. The spiders eaten by the thrush belong largely to the order Phalangida, commonly known as 'harvest men' or 'daddy-long-legs.'

Vegetable food.—The vegetable food of the thrush consists practically of fruit either wild or cultivated. A few weed seeds were found in several stomachs, but they amount to only a trace. It is probable that the greatest harm done by this bird is to the cherry crop, though undoubtedly it eats the later fruits to some extent. In May and June the fruit eaten reaches 41 and 38 percent, respectively, and this probably represents the greatest injury which the bird does, as most of the fruit was the pulp and skins of cherries. From June onward seeds of blackberries and raspberries (Rubus) were frequently found in stomachs, but as these berries are both wild and cultivated it is impossible to tell how much came from gardens. One stomach taken in early June contained seeds of the twin berry (*Lonicera involucrata*). Seeds of the elderberry (Sambucus) were abundant in stomachs taken in the late summer and fall, and indicate that this fruit constitutes a very considerable portion of the vegetable diet of the thrush at that season. Besides these were seeds of the pepper tree, of Solanum (a weed), and one stomach contained fruit of the coffee berry (*Rhamnus californica*). A few seeds of poison oak were found in two or three stomachs. The greatest amount of fruit was eaten in September, and reaches a total of over 80 percent, but as the number of stomachs is not as great as could be desired the result can scarcely be considered final. Moreover, a large part of this was wild fruit.

FOOD OF YOUNG.

Among the stomachs examined were those of 25 nestlings taken in June and July. Their approximate ages and dates of capture are given in the following table:

Brood No.	Number of young.	Age (approximate).	Date of taking.
		Days.	
1	Three	2	June 8
2	Four......	8	June 8
3	Three	4	June 15
4	Three	14	June 19
5	Three	4	July 21
6	Two......	3	July 25
7	Two......	14	June 13
8	Five......	7	July 16

Taking the collection as a whole their stomachs contained 92.6 percent animal matter to 7.4 percent of vegetable. Caterpillars aggregate nearly 27 percent and were found in every stomach but 7. No other element was so abundant. Beetles collectively are next in importance, with 22 percent. Of these the useful Carabidæ amount to 7.7 percent and are very irregularly distributed. All the remainder are more or less harmful species. Bugs (Hemiptera) aggregate 13.8 percent. Five families of these were identified, viz., stink-bugs, leaf-hoppers, tree-hoppers, shield-bugs, and cicadas. Ants and a few other Hymenoptera amount to 12 percent, and spiders to exactly the same. These last were mostly harvest-men or daddy-long-legs (Phalangidæ). A few miscellaneous insects amount to 6 percent, which makes up the whole of the animal food. Four stomachs of the russet-back contained remains of grasshoppers and three of these were nestlings. Carabid beetles were eaten by the young birds to the extent of 7.7 percent, which is more than three times the amount eaten by the adults. This is rather singular, for most of these insects are very hard-shelled and not at all the kind of food usually selected for young birds. Another interesting point is that all were contained in the stomachs of broods Nos. 2, 4, and 5. None of the other nestlings' stomachs held a trace of them.

The vegetable food amounts to 6.8 percent of fruit, with less than 1 percent of two or three other things. The fruit was nearly all either blackberries or raspberries, which were found in 11 stomachs, with twin berries in 1. One seed of filaree and some rubbish made up the rest of the vegetable food.

While the above affords a general idea of the food of these nestlings as a whole, there are some differences in the food of the different broods, which may be worthy of notice. The stomachs of broods Nos. 1, 2, and 6 contained no vegetable matter, as was the case with one each of broods 3 and 5. Broods 4, 7, and 8 had all eaten vegetable food, but more than four-fifths of the whole was contained in the stomachs of broods 7 and 8. The average percentage for these two broods was over 22 percent, or about three times that of the whole. Again, Hemiptera, in the stomachs of broods Nos. 1 to 7, inclusive, amount to an average of less than 4 percent, but in brood No. 8 the average per stomach is over 53 percent of the food. Spiders were found in nearly every stomach of broods 1 to 4, while the other four broods contained very few. These facts indicate that birds exercise comparatively little choice as to the exact nature of their food, but take that which is nearest to hand. With a brood of hungry young incessantly clamoring for supplies little opportunity is afforded the busy parents to select precisely the kind of insects best adapted to the wants of the young. Nature teaches that insect food and not vegetable is needed and the gaping mouths are filled with the nearest obtainable supply.

In addition to the examination of stomachs of nestling thrushes field observations were made on the feeding of the young by the parent birds. Two nests of this species in the town of Hayward, Cal., were observed during several days in June and July, 1901. Each nest was watched for two one-hour periods on as many days as possible, and the number of times that the young were fed was carefully noted.

It may be said, to begin with, that the stomachs of young birds are kept constantly full during the hours of daylight.

Nest No. 1 was situated on a tree on the bank of a small creek on the edge of an orchard. When first observed, there were three young in the nest, apparently about five days old. This nest was watched for one hour from 9.40 a. m. on June 30, and the young were fed six times, but, as both parent birds came to the nest once with food in their beaks and went away without feeding the young, it is probable that they were not quite satisfied as to the intentions of the observer. At 4.25 p. m. of the same day another hour was spent in watching the nest, and the young were fed 11 times. On July 1, beginning at 8.30 a. m., 7 feedings occurred in one hour. This nest was not again watched until July 3 at 8.40 a. m., when the young were fed 8 times during the hour. In the afternoon of the same day, beginning at 3 o'clock, 12 feedings were observed in one hour. The last observation of this nest was made on July 5, beginning at 9 a. m. In an hour 13 visits with food were noted. In the case of this brood there were 57 feedings in six hours, or an average of 9½ feedings per hour. As there were three young, each one must have been fed a little more than three times per hour.

Nest No. 2 also contained three young, but they were only about 2 days old when first visited. The first observation was on June 30, at 3.20 p. m., and the following hour the young were fed 8 times, and as the weather was cold the mother bird spent a number of minutes on the nest warming the nestlings. On July 1 another hour was spent in watching the nest, beginning at 9.30 a. m., and only 4 feedings were observed. It was, however, a cold, windy morning, and one or other of the parent birds remained on the nest all the time, leaving only when the mate brought food and took its turn brooding. The necessity for keeping the nestlings warm evidently prevented the parents from feeding them as often as customary. On the morning of July 3, although the weather was still rather cool, the birds seemed to be making up for the scanty feeding of the previous days, for they were observed to feed the young 15 times in an hour, beginning at 9.40 a. m., although they still took turns in warming the young for a few minutes at a time. In the afternoon of the same day, beginning at 4 o'clock, 8 feedings were noted in an hour. On July 5, beginning at 10 a. m., the parents were seen to feed the nestlings no fewer than 18 times, although one of them spent several minutes upon the nest three times during the hour. In the afternoon of that day 11 feedings were noted, in the hour beginning at 3.30, and 3 times one of the parents brooded the young, remaining once for six minutes. The next observation on this nest was made on July 6, during the hour from 7.50 a. m., and 12 feedings were noted. On July 7 the last observation was made, beginning at 3.20 p. m., and 11 feedings were noted. In this case there were 87 feedings in eight hours, or an average of nearly 11 per hour.

Considering both nests together, as each had the same number of young, we have 144 feedings in fourteen hours. Now at this time of year there are just about fourteen hours of available daylight, so that 144 feedings may be considered as an average day's work for a pair of parent birds, and as signifying the destruction of at least 144 insects, probably several times that number. Each of the three young must have been fed 48 times, which means that each stomach was filled to its full capacity several times during the day, another illustration of the fact that the digestion and assimilation of birds, especially of young ones, is constant and very rapid. This is further shown by the fact that when attempts have been made to raise young birds the experiments in most cases have failed because the nestlings were not fed often enough and actually starved to death. Young birds thrive best when fed a small quantity of food at short intervals rather than greater quantities at longer periods.

SUMMARY.

From the foregoing it appears that although this thrush eats considerable fruit it is not a pest to the fruit grower. Cherries seem to be the only kind eaten to any considerable extent, and in the later summer wild fruit forms a large part of its vegetable diet. This thrush does not aid in the destruction of the seeds of noxious weeds.

In its insect diet the russet-back thrush is almost wholly beneficial. as it eats but few predaceous beetles or other useful insects. As young thrushes are fed almost exclusively upon insects, and as they eat almost continuously from morning till night, they must destroy an enormous number of these harmful creatures. From our present knowledge of its food and general habits, the russet-back thrush must be considered as one of our positively beneficial birds.

HERMIT THRUSH.

(*Hylocichla guttata.*)

The hermit thrush occurs in the valley and foothill parts of California only as a winter visitant. Thus it can destroy no fruit, except perhaps olives, and thus far no complaints have been made against the species in this respect. Although the bird has not yet attracted attention by depredations upon fruit, it may be well, nevertheless, to glance at its food habits as indicated by the contents of 68 stomachs. These were mostly taken in or about the Bay region, while a few came from the southern part of the State. Examination of the contents of these stomachs shows animal matter to the extent of 56 percent and vegetable 44 percent. The proportion of the two elements varies little in the different months.

Animal food.—Hymenoptera, mostly ants, constitute the largest item of the insect food. They amount to 24 percent, and appear to be eaten regularly in every month. This record is better than that of the russet-back. Caterpillars come next in importance, and form 10 percent of the food. They seem to be eaten rather more freely in February and March than in other months, though they are taken at all times of year. Predatory beetles (Carabidæ) are noticeable by their absence, as only a few remains of them appear. Beetles of other families, all harmful species, form 11 percent of the food. Weevils, or snout-beetles (Rhynchophora), constitute more than two-thirds of these, which would seem to indicate that they are a favorite food. When we consider that the carabids live on the ground, and are the most abundant and most easily obtained of any of the common beetles, and note how few of them the hermit thrush eats, while on the other hand it eats many snout-beetles, which, living to a great extent on trees, are generally much more difficult to find, we are forced to the conclusion that the latter are a preferred food, and that they are purposely sought for. Other insects, with some spiders and a few miscellaneous articles of diet (Oniscus), amount to about 12 percent. As in the case of the russet-back thrush, one stomach of the hermit contained the bones of a salamander.

Vegetable food.—The vegetable food is made up of two principal components—fruit and seeds. The former amounts to 29 percent of the whole, and is composed of wild species, or of old fruit left on trees and vines. A few stomachs contained seeds of raspberries, which, of course, must have been old, dried-up fruit. Seeds of the pepper tree and mistletoe were the most abundant and, with some unidentifiable pulp and skins, make up the complement of fruit. The hermit thrush eats more seeds than the russet-back, but does not stand high as a weed destroyer. Seeds of all kinds amount to 14 percent of the food, but only a few are usually reckoned as weed seeds. The most abundant seed was poison oak (*Rhus diversiloba*), which was found in a number of stomachs. While this plant is not usually classed among weeds, it is really a weed of the worst description, since it is out of place no matter where it is. It is unfortunate that birds in eating the seeds of this plant do not destroy them, but only aid in their dissemination.

SUMMARY.

On the whole, the food of the hermit thrush is remarkably free from useful products, destruction of which is a loss to mankind. The worst that can be said of the bird is that it eats and scatters the seed of poison oak, but it does not do this to a marked degree.

WESTERN ROBIN.

(*Merula migratoria propinqua.*)

In most of the valleys of California the robin is a winter resident only, and would be of little economic importance did it not possess a voracious appetite, the satisfaction of which occasionally leads to lamentable results. Of its summer food we know almost nothing, except what may be inferred from its list of edibles while in the valleys, and by comparison with the diet of its eastern relative. The two birds are so nearly alike that probably in the same environment they would eat practically the same things.

In investigating the food of the western robin 74 stomachs were examined. They were taken in every month from September to June, inclusive, except May. This number is entirely too small to be used as a basis for final conclusions, but it suffices to give a hint as to the differences, if any there be, between the food of the eastern and western races. Only one stomach was taken in each of the months of September, October, and June. The others are well distributed through the remaining months. Discarding returns from the three months mentioned, 71 stomachs remain, from which a fairly reliable idea of the winter food of the robin in California may be obtained.

In the first examination we find 40 percent of animal food to 60 of vegetable. The food of eastern robins for the whole year contains 42 percent of animal matter to 58 percent of vegetable, and during the six months beginning on November 1 the amounts are: Animal 35 percent and vegetable 65 percent. If, however, our study is restricted to the three winter months, we find that the eastern robin eats 18 percent of animal food and 82 percent of vegetable, while for the same period the western one consumes 22 percent animal and 78 percent vegetable. These comparisons do not indicate essential differences in the food of the two birds. The western bird eats more insects during the winter months because on the west coast insects are more abundant and more easily obtained at that season than in the East. Confining attention, however, to the six months beginning with November, the eastern bird eats a greater percentage of insects. It is almost certain that if the material were at hand to illustrate the food of the western robin during the remainder of the year, the bird would be found to eat a much larger percentage of insects than in the six months covered by this investigation.

Animal food.—Beetles of various families are the largest item of animal food. The greater number were eaten in April, when they amount to over 54 percent of the whole food for the month. They were distributed among several families, but the most conspicuous were the snout-beetles, or weevils, which aggregated 25 percent. This is a favorable showing for the robin, for these beetles are among the most harmful insects with which the fruit growers and farmers have to contend. The average percentage of beetles for the whole six months is about 13 percent of the food. Caterpillars are next in order of abundance and amount to over 4 percent. The remainder of the animal food is made up of various insects, of which no order claims preeminence, and of a few angleworms.

Vegetable food.—The bulk of the vegetable food from November onward is cultivated fruit. After this month it gradually falls off, and very little was found in stomachs collected in March and April. With the exception of olives, the bird can obtain no fruit of value after the 1st of November, and as olives were not identified in any of the stomachs it is probable that most of the fruit consumed was worthless, having been left after the crop was gathered. The following fruits were identified: Grapes in 5 stomachs, figs in 3, prunes in 2, pear, apple, and blackberries in 1 each. Of wild fruit, pepper berries were found in 17 stomachs, mistletoe berries in 2, and fruit not positively identified in 11. Pepper berries evidently are the favorite, since not only were they found in the greater number of stomachs, but 1 stomach contained 24 and another 28 of these berries. Two stomachs contained wheat and 3 had weed seeds, but dry seeds are evidently not favorite food with the robin.

Destruction of olives.—From the foregoing the robin would not appear to do much damage, or at least not more than is amply paid for by the insects it destroys. But, unfortunately, more is to be said about its food habits, which does not redound so much to its credit. In certain years when their customary food is scarce, robins appear in the valleys in immense numbers, and wherever there are olives they eat them so eagerly and persistently that the loss is often serious and occasionally disastrous. Sometimes, indeed, it is only by the most strenuous efforts, with considerable outlay of labor and money, that any part of the crop can be saved. Fortunately, such extensive damage is not done every year, although here and there the olive crop may suffer.

There is probably no more striking example of exceptional and intermittent damage to fruit by birds than an instance which occurred in the winter of 1900–1901. In that year the olive orchards in various parts of California were invaded by immense numbers of robins, which ate the fruit and in some instances destroyed the whole crop. In orchards where persistent effort was made to destroy and drive them away they still ruined from one-fourth to one-half of the yield. Olive orchards in Santa Clara Valley especially were afflicted. Mr. Paul Masson, who owns two orchards near Saratoga, as quoted by the San Jose Mercury of January 17, 1901, says:

> In my largest orchard of about 500 trees adjoining a larger orchard of about 50 acres on the El Quito farm, which is owned by E. E. Goodrich, are thousands of robins, which are destroying all the fruit on the trees. About two months ago I estimated that my trees would yield about 4 tons of olives, but Sunday, when I visited my orchard, I found the fruit would not be worth picking.
>
> I killed some of the robins, and upon examination found as many as five or six whole olives in the crop of each bird. Besides those which the bird had swallowed whole, many olives are pecked so that they are spoiled for market. Sunday there were not less than 50,000 robins on my place, and they are equally as plentiful on El Quito farm.

Mr. Edward E. Goodrich, the owner of El Quito farm and olive orchard, quoted by the same authority, says:

> The so-called robin is a destructive pest to an olive orchard. A crop can not be saved when the migration of the robin corresponds exactly with the maturity of the olive, as it does this year, except by immediate picking, which is practically impossible, or by shooting so constantly as to prevent steady consumption. * * * In 1898 my crop was 130 tons, and should have made about 4,000 gallons of oil. Owing to the lack of rain the result was about 2,750 gallons, of the value of $11,000. Now, that crop could have been wiped out in ten days by robins if they had been here as they were this season and no shooting had been done. So far as my foreman could estimate, before the birds descended upon the place, he placed the crop at a probable 3,000 gallons, which means when sold from $12,000 to $16,000, according to prices, and that would have been utterly destroyed but for the constant shooting the last ten days.

As it was, Mr. Goodrich placed his loss on the olive crop through the devastations of the robins at 25 percent of the whole, or about $5,000, while his foreman, in an interview with the writer, estimated the loss at 50 percent. He stated also that robins were so numerous that he killed 7 in a tree at a single shot.

The San Jose Mercury also states:

> A representative of the Mercury visited the El Quito olive orchard to see what the facts were in this matter. He found a force of men picking the fruit as rapidly as possible, and he also saw thousands upon thousands of robins doing the same thing. On his way out he occasionally saw a single bird on the fence or in a prune tree, but when he reached El Quito the sky was streaked with robins flitting about and having a gala time of it. Men were scattered about through the orchard with guns, and every few minutes the report of one of these would set the robins to flying, but in an instant they would settle down again and resume their feast.

Hon. Ellwood Cooper, of Santa Barbara, one of the largest olive growers on the Pacific coast, in a letter dated January 25, 1901, says:

> The robin is a terrible pest to olives. The birds do not always appear to come to the coast. My first experience was some fifteen years ago. The olives were late in ripening. I was as late as March making oil. The robins appeared to come in by the thousands. My last orchard that year was about one-half mile in length. The pickers were at one end. I had a man with a gun at the other, but they would attack the middle, and when the gunner would reach them they would fly to the end he left. This year they have been particularly bad. My boys reported that the birds, mostly robins, picked more olives than they could. The foreman of the pickers told me that he had knocked from a tree one-quarter of a sack and went to dinner; when he returned not an olive was on the ground. I know that on the ground in one orchard where the rain had caused to fall as many olives as would fill a bushel basket, in a week not one would be seen. The robins do not seem to be able to pick the olives so rapidly from the trees, but peck at those that are commencing to dry, knock them to the ground, then get them. The birds at this writing are in all my orchards by the thousands. They do not appear every year. It has been my theory that the native berries in the Sierra some years are not in sufficient quantities for food.

In the last sentence Mr. Cooper has probably suggested the true cause of the trouble. There is a crop of olives every year and the number of robins fluctuates little, but they rarely attack olives because usually their native food abounds. Where this fails the hungry birds shift about until they find a substitute.

SUMMARY.

With the exception of such sporadic cases as the above, the food habits of the robin are for the most part of a beneficial, or at least harmless, character. In the eastern part of the country very little damage by the robin is reported, though it is one of the most abundant species. This is probably largely owing to the plentifulness of wild fruits throughout the season. The trouble in California is that the robins from an extensive region concentrate into a comparatively small area and, finding an abundant supply of palatable food, feed upon olives to the exclusion of all other food.

Were the hills and canyons of California as well supplied with wild berries as are the corresponding places in the Appalachian region, it is doubtful if such devastations of the olive crop would ever occur.

Since failure of the natural food supply of the robin is only occasional and can not be anticipated in advance, no direct safeguards against the bird's inroads are possible, though the planting of pepper and other berry-bearing trees about the orchards would materially aid in protecting the olive crop. The prompt and unsparing use of the shotgun when the emergency occurs, even though it seems to be the only practicable method to save the crop, is much to be deprecated, since the destruction of robins, which in the main are useful birds, is a loss to the community.

WESTERN BLUEBIRD.

(*Sialia mexicanus occidentalis.*)

The western bluebird has the same gentle, quiet demeanor that characterizes its relative of the Eastern States. It has not yet, perhaps, become quite so domestic as that species, but still is much inclined to frequent orchards and the vicinity of farm buildings. While the eastern bluebird usually nests either in a hole of an orchard tree or in the box specially provided for its use, the western species has not yet fully abandoned its habit of utilizing forest trees as nesting sites, and often may be found in lonely canyons or among the hills far from the abodes of man. The orchards of California as yet are hardly old enough to offer many hollow trees as nesting places of the kind so dear to the heart of our gentle friend. There is no reasonable doubt that in time the western species will become as domestic as the eastern one. A nest was found by the writer in a hollow tree in the home orchard of a ranch, only a few rods from the house. It contained six young, which would indicate that the bird is a prolific breeder, in this respect also resembling the eastern species.

The western bluebird is less migratory than the eastern and does not entirely desert the United States in winter; so its good work is continuous. As insects are active in California in every month the bird is able to support life even if there is no other food. Moreover, the insects eaten in winter count more in the reduction of these pests than do those taken after the spring broods are out. Insects that live through the winter are the stock by which the species is perpetuated, and the destruction of a few at this time is equivalent to the death in summer of hundreds or thousands.

The food of the bluebird consists of elements whose consumption is almost wholly a benefit to the farmer. Four-fifths of it is insects; only a small portion of these are useful, and these to a limited extent.

In the investigation of the food of the bluebird 187 stomachs were examined. This number is not so large as could be desired, and, moreover, was rather irregularly distributed over the year. Only one stomach was obtained in May, and only one in April, while the number for several other months are too few. Geographically they fairly well represent the fruit-growing regions of the State from as far south as San Bernardino northward to Santa Rosa. The food found in the stomachs consists of animal matter, 82 percent; vegetable, 18 percent.

Animal food.—Of the animal portion a little less than 12 percent consists of predaceous beetles (Carabidæ), which are usually reckoned as useful. There are, however, many exceptions to this rule, and since most of the species of this family are wonderfully abundant it is not probable that the bluebird does much harm by eating them. It is believed, moreover, that this record of Carabidæ is above the normal, for the one bird taken in April had eaten 90 percent of these beetles, thereby raising the average of the whole. In August, on the other hand, not one of the five birds examined had eaten a carabid. Had these months been omitted from the reckoning the average would have been reduced to about one-third of the present figure, which is probably much nearer the truth.

Other beetles amount to over 17 percent of the food, and were distributed among about a dozen families, all of them harmful, except three or four ladybirds (Coccinellidæ), which are useful.

Caterpillars evidently are a favorite food, and probably are eaten in every month, though evidence is wanting for April and May. They amount to over 17 percent of the year's food. Few of these insects are eaten in spring and early summer, many in fall and winter. As practically all caterpillars are harmful, this item of diet counts entirely in the bird's favor.

Grasshoppers and crickets, mostly the former, were eaten in every month except April, but a greater number of stomachs would probably give a different result. They amount to a little less than 24 percent of the year's food. They appear in the stomachs of western birds at a somewhat earlier date than in those of eastern species. In the Atlantic and Central States, August is preeminently the season of grasshoppers, and in that month they constitute the principal article of diet of many species of birds. The western bluebird eats grasshoppers in March to the extent of about 11 percent of its food. In June they amount to over 38 percent, and in July reach a maximum of nearly 49 percent, or nearly half of all that it eats. In September they amount to 40 percent, but decrease rapidly from that time.

Bees and wasps (Hymenoptera) are not largely eaten by the bluebird, and flies scarcely at all, as the aggregate for the year amounts to only four-tenths of 1 percent.

In the summer bugs (Hemiptera) are eaten to a moderate extent. The species belong mostly to the family of 'soldier bugs' (Pentatomidæ) or, as they are sometimes called, 'stink-bugs,' for they have a vile odor and when taken into the mouth with a berry are not agreeable to human taste. The total percentage of wasps, flies, bugs, and a few other insects is a little less than 10 percent of the whole food.

Spiders are eaten to some extent throughout the year, but never in great numbers. The greatest number are taken in February, about 6 percent. The total average for the year is 2 percent. One stomach contained the lingual ribbon of a snail.

Vegetable food.—The bluebird asks practically nothing of man in the way of vegetable food. It is evident that it is not a lover of seeds, as is the linnet, and with abundance of them at hand, eats few or none. In 2 stomachs several small unknown seeds were found, which may have been swallowed accidentally. Not a kernel of grain had been eaten. Fruit constitutes nearly the whole vegetable portion of the food, and was distributed as follows: Elderberries (Sambucus) in 19 stomachs; grapes in 12 stomachs, all in the month of October or later; blackberries or raspberries (Rubus) identified in 4 stomachs; pepper fruits in 2 stomachs; figs in 1 and mistletoe berries in 1. Besides these 9 stomachs contained pulp or skins that could be identified only as fruit. From this it appears that elderberries are the favorite fruit of the bluebird. Fortunately these are nearly always to be had in California. Most of the grapes eaten probably were waste fruit, as many of them were consumed in December and other winter months.

FOOD OF YOUNG.

Among the stomachs examined were those of several nestlings about a week old. They were of interest as showing how large a proportion of animal food is given to the young. In one brood of six the only vegetable food found was a single piece of plant stem, which was probably given accidentally with other food, and should properly be classed as rubbish. The real food consists of grasshoppers and crickets 90 percent, beetles 3 percent, and the remainder made up of bugs, caterpillars, and spiders. In another brood of four, grasshoppers and crickets constituted 97.5 percent of the food, and 1 stomach contained nothing else. The remains of 11 grasshoppers were found in one of these stomachs, and 10 grasshoppers, a cricket, and a beetle in another. The only vegetable matter found in these 4 stomachs was a single seed of Polygonum.

Besides the stomachs of the western bluebird discussed above, 14 stomachs of the Arctic bluebird (*Sialia arctica*) were obtained. They were taken in fall and winter, and, while so small a number is not sufficient for positive conclusions, it may be said that the character of the food closely resembles that of the other species in the same months.

The two species eat about the same proportion of animal and vegetable food; the animal part consists of the same orders of insects, while the vegetable part is made up of the same varieties of fruit. In short, it may be said that if there are important differences in the food habits of the two birds the evidence at hand fails to establish the fact.

SUMMARY.

It seems scarcely necessary to comment on the foregoing statements with regard to the bluebird's diet in its economic relations. That the bird is an eminently useful species is so patent that it hardly needs to be pointed out. Whatever harm fruit growers have suffered from birds, none of it can be laid at the door of the bluebird.

List of insects identified in stomachs of bluebirds:

COLEOPTERA.

Coccinella t. californica.
Hippodamia convergens.
Polycaon stoutii.
Aphodius rugifrons.
Blapstinus dilatatus.
Blapstinus sulcatus.
Blapstinus pulverulentus.
Rhigopsis effracta.
Balaninus sp.
Sitones sp.

HEMIPTERA.

Saissetia oleæ.
Sinea diadema.

HYMENOPTERA.

Messor andrei (ant).

Insects also were identified as belonging to the following families:

COLEOPTERA.

Carabidæ.
Staphylinidæ.
Coccinellidæ.
Histeridæ.
Elateridæ.
Buprestidæ.
Lampyridæ.
Ptinidæ.
Scarabæidæ.
Cerambycidæ.
Chrysomelidæ.
Tenebrionidæ.
Rhynchophora (superfamily).

HEMIPTERA.

Reduviidæ.
Capsidæ.
Lygæidæ.
Pentatomidæ.
Corimelænidæ.
Scutelleridæ.
Jassidæ.
Coccidæ.

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BIOLOGICAL SURVEY—BULLETIN No. 31

C. HART MERRIAM, *Chief*

AN ECONOMIC STUDY OF FIELD MICE

(GENUS *MICROTUS*)

BY

DAVID E. LANTZ
ASSISTANT, BIOLOGICAL SURVEY

WASHINGTON
GOVERNMENT PRINTING OFFICE
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., August 1, 1907.

Sir: I have the honor to transmit herewith, as Bulletin No. 31 of the Biological Survey, an economic study of field mice, by David E. Lantz. Field mice are so generally distributed throughout the United States and at times are so numerous in certain regions that they do serious damage to gardens, nurseries, orchards, and forests. The several species therefore possess an economic importance quite out of proportion to their size. The present bulletin gives a concise account of their distribution and general habits, the nature of the damage they do, together with methods of prevention, the best means of limiting their increase under ordinary circumstances, and of reducing their numbers when, by reason of excessive multiplication, the injuries they inflict are serious.

Respectfully,
H. W. Henshaw,
Acting Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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AN ECONOMIC STUDY OF FIELD MICE.[a]

INTRODUCTION.

The present paper deals with the habits of the common field mice[a] of the United States, the conditions which often favor their enormous multiplication, the natural enemies which aid in their repression, and the agencies which farmers may employ to avoid losses by the animals. Small as these pests are, they inflict enormous injury upon the crops of the country. The aggregate loss to the farmers from this source averages not less than three millions of dollars annually, and in some years is much greater. The major portion of this loss is preventable, and the object of this bulletin is to acquaint farmers, orchardists, nurserymen, and others with the most practical preventive methods.

Among the more interesting facts connected with wild animals are the sweeping changes in the relative numbers of certain species to be noticed from year to year in almost every locality. Species that are abundant one season may be rare or entirely absent the next; or they may gradually increase or decrease in numbers through a series of years until disaster results from their overabundance, or the species becomes practically extinct. Sometimes wild animals increase in numbers so suddenly that the change has been likened to a tidal wave, and ignorant people have regarded the invasion as of miraculous origin. The belief that crickets, locusts, frogs, and even mice sometimes fall from the clouds is still held in many countries.

The careful observer, however, sees little mystery in the phenomena mentioned. He has studied the general habits of animals—their food, their powers of reproduction, their migrations, the checks on their increase due to natural enemies, disease, and varying climate—and consequently he attributes sudden changes in their numbers to known causes. In such changes he recognizes, especially, the influence of man, both direct and indirect, and his responsibility for interferences that greatly modify the operations of nature.

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[a] The term "field mice" applies equally well to several groups, or genera, of mice which occur in cultivated areas and meadows of the United States, but in this paper it is restricted to the most widely known group, the genus *Microtus*.

Outside the insect world the most striking examples of occasional excessive multiplication of a species are afforded by rodents. The invasions of rabbits and rats are familiar, but no rodents exhibit the tendency more forcibly than the *Microtinæ*, a subfamily which includes lemmings, voles, and muskrats. The lemmings and voles, especially, are noted for those peculiar waves of increase that astonish observers and bring disaster in their wake. The most noted example is afforded by the somewhat periodic migrations of lemmings (*Lemmus lemmus*) in Norway and Sweden.

These animals live in the higher plateaus of Scandinavia. Here during several favorable years they increase in geometrical ratio until the food supply gives out and hunger impels great hordes to migrate into the lower valleys. Once started on their journey they continue in the same general direction in spite of all obstacles. They travel in vast armies, swimming lakes and streams, living on the products of the soil, and carrying calamity to farmers. They breed on the journey, lingering only until the young are strong enough to travel or until food is exhausted. They are constantly the prey of natural enemies which gather in their wake, and are destroyed ruthlessly by man; so that in spite of an enormous natural increase, the vast army gradually melts away. Usually disease breaks out and helps to decimate them, so that as a rule comparatively few reach the final barrier to their march, the sea. After a short delay the survivors, ignorant of the nature of the barrier, plunge into the water and essay its passage, swimming until they perish.[a] The migrations usually cover a period of two years, but are sometimes prolonged to three. None of the migrating animals return to their homes, and they are entirely absent in the lower valleys until the next migration.[b]

The economic vole (*Microtus œconomus*) of Siberia performs somewhat similar migrations. Writing of it over a century ago Thomas Pennant said: "They in certain years make great migrations out of Kamtschatka; they collect in the spring and go off in incredible multitudes. Like the *Lemmus*, they go in a direct course and nothing stops their progress, neither rivers or arms of the sea: in their passage they often fall a prey to ravenous fishes and birds, but on land they are safe, as the Kamtschatkans pay a superstitious regard for them; and when they find them lying weak or half dead with fatigue on the banks, after passing a river, they will give them all possible assistance. They set out in their migration westward. From the river Pengin they go southward and about the middle of July reach Oshotska and Judoma, a tract of amazing extent. They return again in October. The Kamtschatkans are greatly alarmed at their migrations, as they presage rainy seasons and an unsuccessful chase; but on their return, expresses are sent to all parts with the good news."[a]

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[a] Prof. Robert Collett, of Christiania, Norway, records that in November, 1868, a steamer sailed for a quarter of an hour through a swarm of lemmings which extended as far as the eye could reach over the Trondhjemsfjord. (Journal Linnean Society of London, Vol. 13, p. 33, 1878.)

[b] T. T. Somerville, Proc. Zool. Society of London, 1891, pp. 655–658. Robert Collett, Journal Linnean Soc. of London, Vol. 13, pp. 327–334, 1878.

Visitations of voles have not been infrequent in the history of the Old World. The earliest records of them are in the Bible[b] and in the works of Homer, Herodotus, and Aristotle. So serious did the Greeks consider plagues of field mice that in their pantheism they had a mouse god (Apollo Smintheus), who was invoked to avert the evil.

Invasions of field mice have not been rare in Great Britain and the Eurasian continent. Blasius records serious outbreaks on the Lower Rhine in the twenties.[c] Brehm, quoting Lenz, gives an account of one in 1856 and of another in Rhenish Hesse in 1861. Brehm himself observed hordes of the animals in 1872 and 1873 on the sandy plains of Brandenburg and in the rich corn lands of Lower Saxony, Thuringia, and Hesse.[d] The chroniclers of England—Holinshed, Stow, Childrey, Lilly, Fuller, and others—record outbreaks of mice in Essex and Kent, 1581, and again in Essex in 1648 and 1660. Later plagues occurred in parts of England in 1745, 1754, 1814, 1825, 1836, and 1863–1867. Severe outbreaks took place in Scotland in 1825, 1864, 1876, and 1892, the last so serious in its effects upon the sheep industry that the British Board of Agriculture appointed a special committee to investigate it. The report of this committee[e] is the most complete and important contribution to our knowledge of field mice thus far published.

A large portion of Hungary was devastated by field mice in 1875 and 1876. In 1875 they were observed to be very numerous in certain districts, and by the spring of 1876 they fairly swarmed in cultivated fields, so that the peasants "doubted whether they had sprung from the earth or fallen from the clouds." They devoured grain, roots, and growing vegetation—corn, potatoes, turnips, and lucern. In the fall they attacked vineyards and shrubbery, and when food was exhausted, began to eat each other. They were finally destroyed by an infectious disease, which killed them by thousands.[a]

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[a] History of Quadrupeds, by Thomas Pennant, 3d edition, vol. II, p. 195, 1793.

[b] "And the cities and fields in the midst of that region produced mice and there was great confusion and dearth in the city." I Samuel, v., 6 (Vulgate version.)

[c] Naturgeschichte der Säugethiere Deutschlands, von Johann Heinrich Blasius, p. 386, 1857.

[d] A. E. Brehm, Thierleben: Säugethiere, vol. 2, p. 390, 1877.

[e] Report of the Departmental Committee on a Plague of Field Voles in Scotland, London, 1893.

In North America, up to the present time, no such calamitous invasions of field mice have been known, although occasionally one or another species increases locally to such an extent as to amount to a plague. Of even greater consequence, however, is the steady drain on agricultural products caused by these rodents over a large part of the country when present in normal numbers.

CLASSIFICATION OF FIELD MICE.

The genus *Microtus* belongs to a subfamily of *Muridæ* known as the *Microtinæ* (formerly *Arvicolinæ*). This subfamily embraces a large number of forms of small and very similar rodents which in some respects resemble true mice, but which are readily distinguished by the robust body, thick head, short ears (whence *Microtus*), and short tail, the last exceeding two-thirds of the length of the body in but one genus, *Fiber* (muskrats).

The *Microtinæ* are divided into two groups, which are commonly distinguished under the names lemmings and voles. Externally lemmings have shorter bodies than voles, and, except in one genus (*Synaptomys*), the tail is shorter than the hind foot, and the palms and soles are without distinct foot pads (plantar tubercles). The two principal genera have the nails on the thumb strap-shaped (ligulate).

Voles have bodies less stout, tails usually longer than the hind foot, and soles and palms always with distinct foot pads. The thumb nails are pointed, not ligulate. There are four genera of voles, all having representatives in the United States, of which the two more familiar are *Fiber* (the muskrats) and *Microtus* (the field mice). The other two genera are of little importance to the farmer. The present paper deals only with the genus *Microtus*.

Voles of the genus *Microtus* are distinguished from members of the other three genera by having rootless molars at all stages of their life. *Fiber* may easily be recognized by its large size, its long, laterally flattened tail, and by its having the feet modified for swimming.

There seems to be no entirely appropriate vernacular name for the mice of the genus *Microtus*. The French call them "campagnols," the Germans "wühlmäuse." English-speaking people outside the United States call them "voles." In the United States they are variously designated as "meadow mice" or "field mice," and locally as "bear mice," "bull mice," "buck-tailed mice," "mole mice," etc. "Vole" is open to the objection that it applies equally well to three other genera and may easily be confused with "mole." "Field mice" will apply as well to other genera and subfamilies of mice, while the term "meadow mice" is not broad enough to include all the species of *Microtus.*

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[a] Report on a Plague of Field Voles in Scotland, Appendix III, p. 76, 1893.

SPECIES AND DISTRIBUTION.

Field mice of the genus *Microtus* have stout bodies, blunt, rounded muzzles, small eyes, and short ears—often completely concealed in the fur. The tail is short and hairy; the soles of the feet are naked or clothed with short hairs, and have five or six foot pads (plantar tubercles). The incisors are broad and not grooved.

The molar teeth in all members of the genus, like the incisors of all rodents, grow continuously throughout the life of the animal and do not develop roots. They are prismatic in form, and the crowns show triangular dentinal spaces surrounded by lines of harder enamel. These curious enamel patterns are of great importance in the classification of the animals, as they are but slightly affected by age and wear and are remarkably constant for each species.

About 165 living species and subspecies of *Microtus* have been recognized (1904), of which about 78 are North American.[a] Eight extinct fossil species have been described, and several of the living forms also have been found fossil.

The genus *Microtus* is of wide distribution, covering practically the greater part of the northen hemisphere outside the tropical zone—America north of the Tropics, all of continental Europe, and Asia, except its southern peninsulas. Great Britain has two species, but Ireland and the principal Mediterranean islands have none. The genus is not found in South America, Africa, Australia, or the Australasian islands. While true mice (*Mus*) are found over a large part of the range of *Microtus*, they do not extend so far northward and occur much farther southward. *Microtus* finds its most southerly extension in the Old World in Palestine and the southern slope of the Himalaya Mountains; in America, in southern Mexico and Guatemala.

The range of a single species is often remarkably great. Thus the typical form of the common meadow mouse of the United States (*M. pennsylvanicus*) occurs over a large part of at least twenty-five States, from Maine to the Dakotas and southward almost to 35° north latitude. If the five subspecies (geographic races) are included, this range is almost doubled in extent. Another species, *M. mordax*, occurs in most of the high mountains from Colorado to California and from Arizona to Alaska. The meadow vole of Great

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[a] For key to the North American species and descriptions the reader may consult N. A. Fauna No. 17, Revision of American Voles of the Genus Microtus, by Vernon Bailey, 1900.

Britain (*M. agrestis*), common from the Orkney Islands to the English Channel, is also distributed over much of northern Europe. Another closely related species, *M. arvalis*, has a still wider distribution in central and southern Europe, and, strange to relate, is found in England as a fossil.

On the other hand, some of the species of *Microtus* are of limited range, a few of them being confined to the summit of a single mountain or isolated on a single small island. The beach vole, for instance, occurs only on Muskeget Island, Massachusetts, while the Gull Island vole (*M. nesophilus*) of Great Gull Island, in Long Island Sound, was of such limited distribution that grading and excavating for fortifications probably resulted in the total extinction of the species.

The several species differ greatly in size. Including the tail, some are even shorter than the common house mouse, while others are as large as a medium-sized rat. The largest species is the Florida water rat (*Microtus alleni*), whose total length is about 320 mm. (12.5 inches). The smallest American species is the dwarf vole (*M. pauperrimus*), whose total length is 115 mm. (4.5 inches). While the tail of field mice is usually very short in proportion to total length of the animal, the various species differ greatly in this particular. The males of many species give off a strong odor, much like that of the muskrat.

HABITS OF FIELD MICE.

While the food habits of the various species of short-tailed field mice are remarkably similar, their breeding and general habits differ greatly. The variety of habitats is most striking. Some species prefer high and dry ground, while others live in low, moist places. Occasionally the same species inhabits both sorts of localities. Some species live in forests, others in the open prairies. Some burrow under the ground like moles, while others make smooth paths or trails upon its surface.

Except in cold weather, nearly all species can temporarily adapt themselves to moist surroundings; but a few seem to be almost as aquatic as the nearly-allied muskrat. This is true especially of the larger species, such as the Florida round-tailed " muskrat " (*M. alleni*) and the European water vole (*M. amphibius*), both of which swim and dive with such facility that they are popularly called " water rats."

NESTS AND TRAILS.

The nests of field mice are compact bunches or globes, composed chiefly of grass blades and other dry vegetable fibers. They are placed in depressions in the ground, in shallow burrows, or supported on grass stems above the ground. In brush piles the writer has found them nearly a foot above the ground. Sometimes they are placed under flat stones or logs or under shocks of grain. The structures are so slight that a day's sunshine will dry them out after a storm, and yet they are so compact that the animals pass the coldest weather snugly housed in them under the snow.

The nests are admirably located with respect to drainage, being so placed that they are not likely to be flooded during excessive rains, and often being in depressions of mounds made by the mice, well above the general surface of the meadows.

Trails, often of great length and worn smooth by constant use, lead to neighboring feeding grounds. As far as possible they are under shelter of old grass, fallen weeds, leaves, and other material. The trails of some species are almost entirely below the surface of the ground, and short tunnels are common with most species. At intervals burrows of varying depth occur, usually but a few inches below the surface. These lead to underground nests, to the roots of food plants, or serve only for refuge from enemies.

BREEDING HABITS.

While most surface nests are for shelter only, sometimes the young, especially of swamp species, are produced in them. However, the young of most kinds are born in underground nests and are rarely seen unless uncovered by accident. They are at first hairless and blind. When discovered in the nest the mother vole slips noiselessly away, sometimes carrying the young attached to her mammæ.

The breeding season includes most months of the year, except midwinter in cold latitudes and periods of long-continued drought. The number of litters in a year thus depends on climate, and especially upon the character and length of the winter. In temperate latitudes in normal seasons from four to six litters are produced. Even the same species in different localities differs much in this particular. That the number of young in a litter varies with the different species may be inferred from the variation in the number of teats. Some species produce normally from two to four young, others from four to eight; but the variation in the same species is remarkable, and depends partly upon climate, but probably more on the scarcity or abundance of food. The largest litter recorded by the field naturalists of the Biological Survey is thirteen, the species being the dwarf vole (*M. nanus*). The period of gestation is not positively known, but probably is about twenty days. Members of the Biological Survey have recorded finding young of the American species in the nests, or females containing embryos, in every month of the year except January and February.

European testimony proves conclusively that, like the lemmings, voles at times increase in numbers abnormally, but the causes are little understood. So rapidly do they multiply at such times that the results are astonishing. Females become pregnant within a few days after giving birth to a litter, and the number of young at a time is abnormal. The published accounts of conditions subsequent to and during such periods are highly interesting.

Dr. A. E. Brehm, quoting Blasius and Lenz, states, concerning the field mice of Germany (*M. arvalis*), that in 1822 in the district of Zabern 1,570,000 were caught in fourteen days. During the same time in the district of Nidda 590,427 were caught, and in that of Putzbach 271,941. In the autumn of 1856 there were so many voles in one district between Erfurt and Gotha that about 12,000 acres of land had to be replowed because of the destruction of the first crop. On a single large estate near Breslau 200,000 were caught within seven weeks and sold to a Breslau fertilizer factory at a pfennig (nearly one-fourth cent) per dozen. Some of the vole catchers caught 1,400 to 1,500 per day. In the summer of 1861, in the neighborhood of Alsheim, in Rhenish Hesse, 409,523 were caught. The local authorities paid 2,593 gulden (about $1,000) for their capture.[a]

Louis Figuier, the French naturalist, writing of the same species, says that the female gives birth to from eight to twelve little ones three or four times in a year, and that multiplication is so rapid at times that "whole districts have been reduced to destitution by this scourge. In 1816 and 1817 the one department of Vendée experienced a loss estimated at £120,000 [nearly $600,000], caused entirely by these animals."[b]

The common meadow mouse of the United States is one of the most prolific of our species. Estimating the normal increase at six young, with four litters in a season, and assuming that there were no checks upon the increase, the results are appalling. A single pair and their progeny in five seasons would amount to nearly 1,000,000 individuals. This calculation is under the mark, since it is based on the assumption that the young do not breed until about a year old. The animals, however, mature very rapidly, and the spring young undoubtedly breed in the fall of the same year.

If a thousand pairs of field mice survive the winter in any neighborhood, the potential conditions for a vole plague are present. If, now, instead of normal reproduction, circumstances bring about a considerable increase both in the number of young at a time and in the number of litters in a season, the probability of a plague is greatly increased. Hence the farmer needs the good offices of every creature that preys upon mice, to supplement the climatic limitations upon their increase and to aid in saving his crops.

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[a] Thierleben: Säugethiere, vol. 2, pp. 387–393, 1877.

[b] Mammalia Popularly Described by Typical Species, L. Figuier, p. 445, 1870.

FOOD HABITS.

Owing to its finely chewed condition, exact determination of the food of rats and mice from stomach examinations alone is very difficult. This is especially true of the species of the genus *Microtus*, whose molars are well adapted for grinding. So complete is the mastication and subsequent maceration of weed and grass seeds, as well as roots and grains, that the cell structure is often destroyed. A fair idea of the food can be gained, however, by a study of the animal's environment, by the color of the stomach contents when bark has been eaten, the odor of wild onions when present, the presence of starch grains revealed by the microscope, or the character of the few perfect vegetable cells that remain. The bits of stems, blades of grass, and leaves of other plants left scattered along the runways are important evidence, as also are the contents of the caches of food in the burrows.

In summer the principal food of these mice is green vegetation and unripe seeds of grain and grasses. As the season advances, ripe grain and seeds take the place of the immature; and in winter bulbous and other roots are in part substituted for stems and leaves. When convenient, and green vegetation is lacking, the bark of trees and shrubs becomes a staple food. It is mainly in winter that apple orchards and young forest trees suffer from attacks of mice. It is generally supposed that such attacks are due to the absence of ordinary food; but this is not always the case, for depredations often occur during mild, open winters when food abounds. Instances also of summer girdling of trees are well attested.

Examinations of stomachs of field mice show that, besides stems, leaves, and seeds of grasses and sedges, the animals eat nearly all kinds of bulbs, tubers, and roots, and occasionally animal food such as snails and crayfish. Outside the list of grains, vegetables, grasses, roots, and barks, which are generally known as staple food of field mice, they have been found eating strawberries and other fruits; roots of wild morning-glory (*Convolvulus sepium*), sweet clover (*Melilotus alba*), and cat-tails (*Typha latifolia*); seeds of iris and primrose (*Primula parryi*); bulbs of tulip, hyacinth, and wild onion; and the tubers of the Jerusalem artichoke (*Helianthus tuberosus*).

The quantity of green vegetation eaten by a single adult field mouse in the course of a year has been calculated at from 24 to 36 pounds. When one considers in connection with this estimate the great numbers of these animals in our meadows, swamps, and forests, the total quantity of food consumed by them appears so enormous as apparently to exceed the productive capacity of the soil. A thousand mice in a meadow would require at least 12 tons of grass or other green vegetation to maintain them for a year.

coarser materials outside, but compact and of finer stuff within, each having a small opening on the side near the bottom. From this opening two or more trails diverge, one usually leading into an underground tunnel which opens at some distance from the nest. Nests intended to receive the young are lined with the softest of accessible materials, often with pappus of milkweed (*Asclepias*) or cat-tails (*Typha*). Such nests are sometimes hidden under grass, brush, or other litter, but more frequently are placed in underground burrows. The normal number of young varies from four to eight, the average being about six.

The trails of meadow mice are interesting subjects for study. The animals take advantage of all sorts of shelter, especially that which is close to the ground. Under fallen leaves and weeds the trails become half tunnels. Even in the open meadow they are often entirely hidden under old grass, and their presence would hardly be suspected from any surface indications. Under the favoring shelter of piles of weeds, grass, or other litter the trails made by the animals are usually more intricate than elsewhere. The accompanying sketch (fig. 1) was made from trails and nests uncovered by removing a pile of weeds.

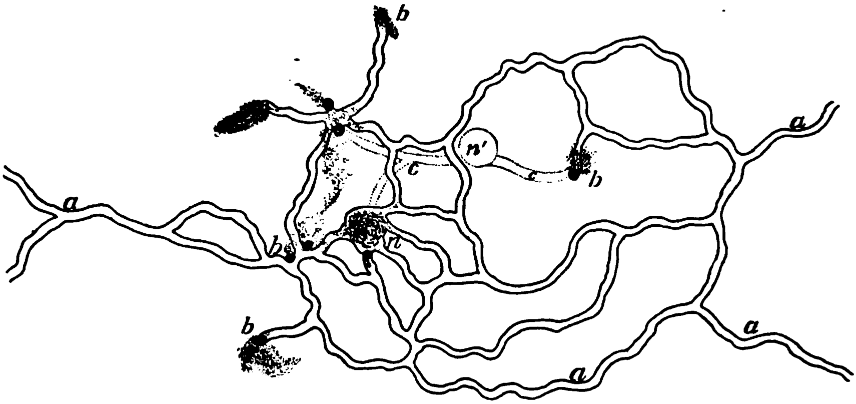


FIG. 1.—Nests, burrows, and trails of *Microtus pennsylvanicus*. *a*, Surface trails; *b*, opening to burrows; *c*, underground tunnels; *n*, surface nest; *n'*, underground nest.

The rapidity with which meadow mice work is surprising. If the nest is destroyed they choose a new site and construct a new nest of fresh materials in a single night. They work both night and day, but are especially active in the evening and early morning. They are less active in the middle of the day, especially in sunlight.

When disturbed in their homes meadow mice rush about with great celerity; but in sunlight especially they do not see well, and are almost as liable to rush blindly toward the point of danger as away from it. When cornered, they stand on their haunches and defend themselves

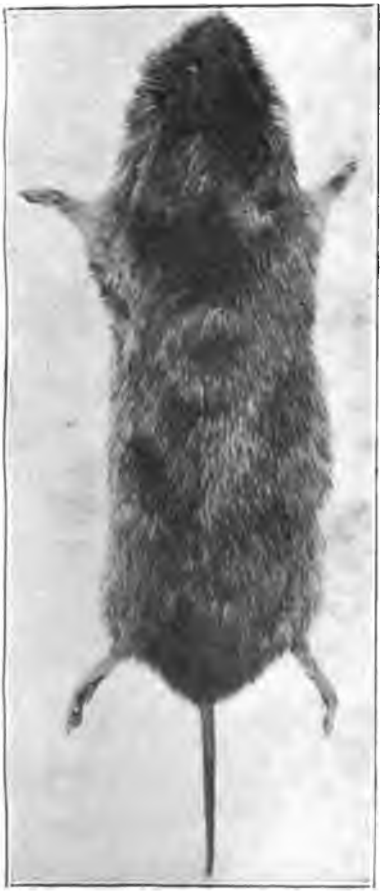


FIG. 1.—MEADOW MOUSE (MICROTUS PENNSYLVANICUS).

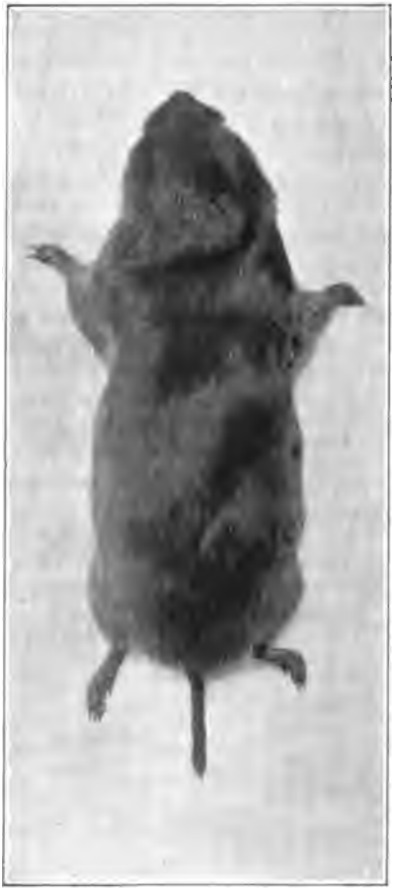
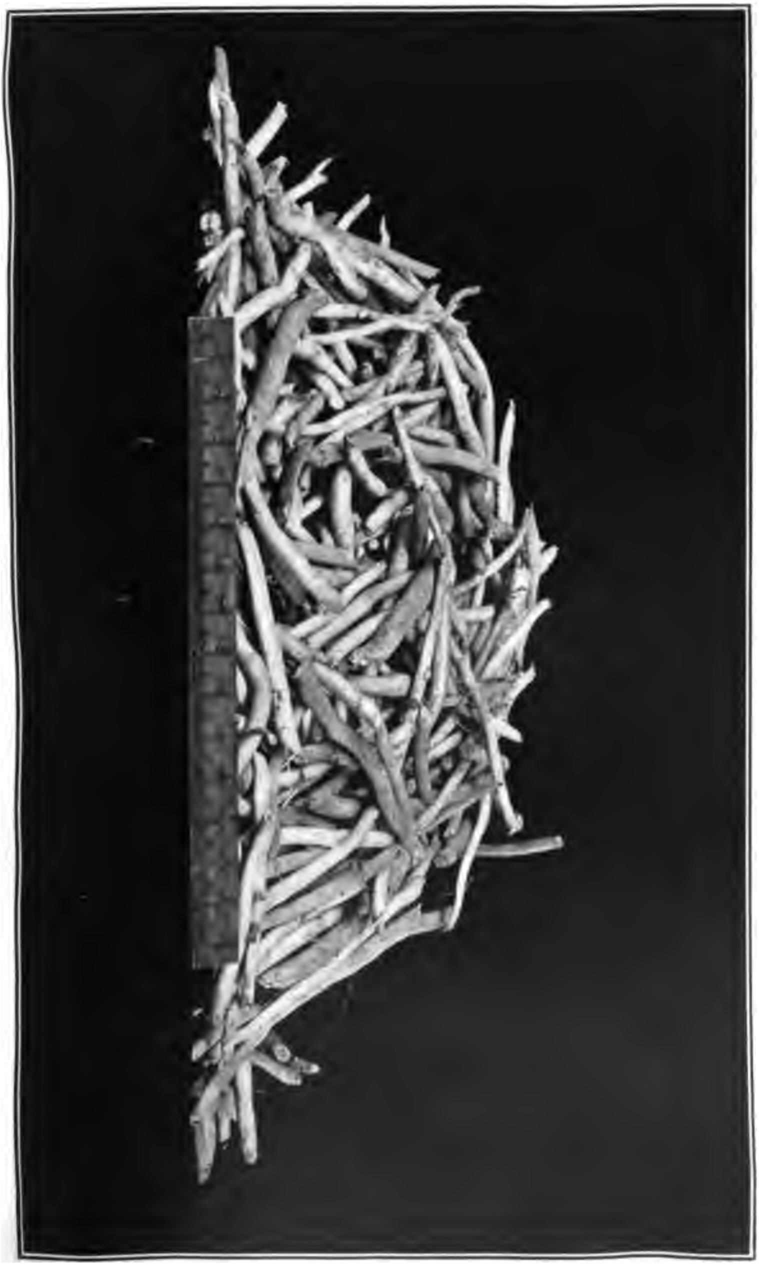


FIG. 2.—PINE MOUSE (MICROTUS PINETORUM SCALOPSOIDES).



Roots of Wild Morning-glory (Convolvulus sepium) Stored Underground by a Pair of Meadow Mice (Microtus pennsylvanicus).

[Weight of roots, 18 ounces. The scale in the illustration is 6 inches long.]

with great valor, and their sharp teeth are rather formidable weapons. Sometimes after capture one seems to give way to uncontrollable anger, and when placed in a cage with others of the same species it is eager to attack all its fellows. When two engage in combat they stand up on the hind feet and fight with claws and teeth, keeping up a constant squeaking.

Meadow mice soon adapt themselves to confinement. They eat almost any food offered and soon become tame. I find, however, that certain succulent roots, particularly those of the wild white morning-glory (*Convolvulus sepium*), are preferred to everything else. This root tastes much like sweet potato and is abundant in swamps and waste places frequented by the mice. While feeding they sit up on their hind legs and use the front paws to handle the roots, after the manner of squirrels.

This species often stores up food in underground galleries. I have several times discovered such hoards, consisting of leaves or succulent stems, but more frequently entirely of the morning-glory roots already spoken of. On March 5, 1907, I collected the contents of such a cache, which weighed 18 ounces (Pl. II).

The species under consideration never lives in barns or outbuildings. Its nearest approach to human habitations is the stackyard or piles of wood or boards left on the edge of orchards or fields near houses. In the far north a closely related species, the Drummond vole (*M. drummondi*), enters houses and barns much after the manner of the common house mouse.

The common meadow mouse is especially noted for long winter excursions from its summer abode, hiding its movements under cover of deep snow. The journeys of the animals are not suspected until the snow disappears, when the trails can be traced to great distances. They reach wheat, rye, clover, and timothy fields and often extend into orchards, nurseries, lawns, and gardens, all of which are injured by the animals. Haystacks or shocks of corn and other grain are sure to suffer if left out over winter.

The Old World species of field mice most noted for extensive ravages of crops, and including such well-known forms as *M. agrestis*, *M. arvalis*, and *M. hartingi*, are very closely related to our common meadow mouse. Many of the more prominent American species, as the Drummond vole (*M. drummondi*), the Peale vole (*M. montanus*), the dwarf vole (*M. nanus*), the Townsend vole (*M. townsendi*), and the California vole (*M. californicus*), belong to the same group. Their wide distribution brings meadow mice into contact with agriculture over great areas, and this fact, added to their prolific breeding, renders the group the most destructive one in the genus under consideration. As farming is pushed northward in the British provinces and as the cultivated areas in the West are extended under the stimulus of the United States Reclamation Service, the danger of serious ravages by meadow mice will increase rather than diminish.

II. THE PRAIRIE MOUSE.

Microtus ochrogaster Wagner.

The prairie mouse is probably second only to the common meadow mouse in the extent of its injury to crops. Outwardly it differs but slightly from the latter species. Its tail is shorter (less than twice the length of the hind foot) and its fur is coarser. In winter the pelage is grayer. The color of the underparts shades into a buff or cinnamon. The contrast between the upper and lower parts of the tail is much sharper than in the common meadow mouse. The foot pads are 5, and the number of mammæ 6 (2 pectoral and 4 inguinal). Its average measurements are about as follows: Length, 155 mm. (6 inches); tail vertebræ, 38 mm. (1.5 inches); hind foot, 21 mm. (0.82 inch).

The prairie mouse occurs in southern Wisconsin, in Indiana, Illinois, Iowa, Missouri, Nebraska, Kansas, and a part of Oklahoma. It lives in the open prairie country, mainly in the Upper Austral zone. Thus it is much more likely to invade crops than if its natural habitat were in swamps. I have found it on the borders of corn and cane fields and in native meadows, as well as in cultivated clover and alfalfa fields. It seems especially partial to fields that have been allowed to lie fallow for several seasons. The soft mixed annual grasses and weeds that partly replace the original prairie cover seem to furnish it congenial surroundings. Close grazing of the open ranges tends to drive out voles, but when ranges are not closely pastured, so that an abundance of old grass is left, prairie mice soon become numerous and appreciably reduce the amount of forage.

In the same manner the prairie mouse invades pastures and neglected orchards whenever dry grass is permitted to accumulate and remain over winter. If no crops are near, the animals subsist on wild herbage, roots, and seeds; but when cultivated crops are accessible their trails soon extend far into the tilled fields.

Nests of prairie mice usually are less bulky than those of the common meadow mouse, but are built in a similar way and in like situations. The number of young at a birth is usually three or four, rarely five or six. In ordinary seasons the first litter is born in April, but in dry, warm springs the time may be fully a month earlier. The number of litters in a season varies with climatic and other conditions. On the whole, prairie mice multiply less rapidly than meadow mice, since the number of young at a birth is smaller, and the long summer droughts and extreme winters of the interior prairies of the West often limit reproduction.

Robert Kennicott's excellent account of this species[a] states that in confinement the animals were practically omnivorous, rejecting but little vegetable food offered them. The amount of food consumed was astonishingly great. Three ate in twenty-four hours, besides other food, the germs from all the kernels of a large ear of corn. They ate raw fresh meat and drank much water.

My own observations of the prairie mouse confirm published accounts. Near alfalfa fields in Kansas I found that the green leaves of this forage plant were the favorite food. This was made evident by the trails leading to the fields and by careful stomach examinations of individuals captured.

In winter the prairie vole sometimes does enormous damage to fruit trees. In this respect it is, if possible, more destructive than the common meadow mouse; and as the fruit industry in the West grows in magnitude this species is likely to become still more troublesome. In Kansas and Missouri, during the winter of 1903–4, many orchards and nurseries were severely injured by the prairie mouse, and during the two following winters the losses were greater rather than less.

This species comes into contact with agriculture in the major portion of eight States lying in the humid section of the central Mississippi Valley. These eight States produce annually more than half the corn, oats, and winter wheat, and more than a third of the hay of the entire United States. Two closely related species of prairie mice (*M. haydeni* and *M. minor*) extend the range of this group on the plains to the west and northwest. Here they are abundant in sections where barley and spring wheat are important crops. The possibility of serious crop damages from prairie voles is, therefore, especially great.

III. THE PINE MOUSE.

Microtus pinetorum scalopsoides (Aud. & Bach.). (Plate I, fig. 2.)

This pine mouse, called also the mole-like vole, has a wider distribution than the typical southern pine mouse (*M. pinetorum*), and therefore is chosen as the representative of the group. The following account of its habits applies equally well to all pine mice.

This animal has the wide, flat skull, the short tail, the small ears, and the short, dense, glossy brown fur characteristic of all the pine mice. The colors, however, are less glossy and the size somewhat larger than in typical *M. pinetorum*. The claws are well developed; foot pads 5; mammæ 4 (2 pairs of inguinal). The average measurements of three New York specimens, as given by Bailey, are as follows: Total length, 125 mm. (about 5 inches); tail vertebræ, 20 mm. (0.78 inch); hind feet, 16.3 mm. (0.64 inch).[a]

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[a] The Quadrupeds of Illinois Injurious and Beneficial to the Farmer. Patent Office Report: Agriculture, 1856, pp. 97–102, 1857.

Owing to their peculiar habits, pine mice are not so well known as are meadow mice. Their natural habitat is the forest, although they are by no means restricted to pine woods or forested areas. While often inhabiting pine woods and the edges of adjacent fields, they live also in forests and copses of deciduous trees, usually on uplands.

The life of pine mice is largely spent in underground tunnels, which so closely resemble those of the mole that generally they are mistaken for the work of that animal. The ridges of loose soil over the tunnel are exactly like those thrown up by the mole, but the inner diameter of mouse tunnels is less. When moles and pine mice live in the same vicinity, the mice often use the runways made by the moles. It is this habit that has helped to bring moles into disrepute with farmers, who blame them for damages inflicted upon potatoes and other crops by pine mice.

In marked contrast with the pine mouse, the mole (genus *Scalopus*) is almost exclusively carnivorous, eating mainly earthworms and insects. While it sometimes cuts off the roots of growing plants when they interfere with its tunneling operations, it apparently eats no roots. Stomach examinations of moles show that they eat a very small percentage of vegetable matter, and this mainly waste corn or other grain previously softened by long contact with wet soil. On the other hand, pine mice eat little insect food, if any, and are largely consumers of vegetable substances. Nearly always when moles are charged with destroying root crops, the real culprits are pine mice.

Thin, open woodlands used for pasture, and thickets along the edges of forests are favorite resorts of pine mice. Like nearly all voles, they prefer moist soil, but it must also be loose and somewhat sandy. From their intricate tunnels under the leaf mold frequent burrows descend into the soil. Some of these burrows are utilized as nesting places. Nests are built also at the surface of the ground, under fallen logs, brush heaps, flat stones, fences, or other shelter.

The number of young at a birth evidently averages less than is usual in the genus *Microtus*, as is shown by the small number of mammæ. Observations as to the number of litters in a season seem to be lacking, but the rate of reproduction is probably less in the pine mice than in any other American group of field mice. Blasius says concerning *M. subterraneus* of Europe, that "it produces five or six times a year three to five young, which are blind for ten days after birth;"[b] and this statement is probably true, with slight modification, for all the species of the group. To compensate for slower multiplication, their liability to attack by natural enemies is much less, owing to their underground existence; so that within their range pine mice are about as abundant as other field mice.

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[a] N. A. Fauna No. 17, p. 64, 1900.

[b] Naturgeschichte der Säugethiere Deutschlands, p. 390, 1857.

Quick and Butler, writing of the food habits of the pine mouse in Indiana, state that it lives upon the tender roots of young hickories, the young sprouts of white clover, the fruit of the red haw, and the tuberous roots of the wild violet (*Viola cucullata*). The writers found all but the fruit buried, some in deposits of a gallon in a burrow, and the caches sometimes extending 18 inches below the surface of the ground. Violet roots predominated in these stores.[a] Kennicott also states that pine mice store acorns and nuts in burrows for winter use. Blasius and Brehm both state that the European species (*M. subterraneus*) prepares such stores. While personally I have never found such deposits, it is probable that our species have this habit to an extent greater than is generally known.

From their homes in woods and thickets pine mice invade fields, orchards, nurseries, dooryards, and gardens, passing always through underground runways. Living in concealment, neither their presence nor the injury they inflict is suspected until the latter is past remedy. Bulbs, planted hopefully in autumn, appear not at all in spring, or only in the shape of sickly plants whose life substance has been gnawed away. Nursery and orchard trees here and there put forth no leaves, and an examination of the roots discloses the nature of the damage.

Potatoes, sweet potatoes, carrots, beets, and other vegetables are eaten by pine mice, both while growing and when stored in pits or lying in piles in the field or garden. Potatoes partly matured or left long in the ground after maturity are eaten, and the injury is attributed to moles, because tunnels supposed to be the work of moles lead to the place of damage. I have investigated numerous cases of such injury and have invariably found either that the tunnels were made by pine mice, or, if mole tunnels, that they were frequented by mice. Traps set in the tunnels at the potato hills captured pine mice, and the starchy material found in the stomachs of those caught proved that they, and not moles, had been eating the potatoes.

Pine mice occur in central and southern Europe, in the eastern United States, and in a limited part of eastern Mexico. Those in the United States occur chiefly in the Upper Austral zone. The typical species (*M. pinetorum*), with bright russet-brown color and glossy mole-like fur, is found only in parts of Georgia, South Carolina, and southern North Carolina. In the last-named State it grades into the subspecies *scalopsoides*, which is much more widely distributed, ranging northward to southern New York (Hudson Valley and Long Island) and westward to Illinois. West of the Allegheny Mountains it occurs mainly north of the Ohio River, except in West Virginia.

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[a] American Naturalist, vol. 19, p. 116, 1885.

The bluegrass vole (*M. p. auricularis*), a form with ears overtopping the fur, which is dark and glossy, occurs in southern Indiana and in Kentucky, Tennessee, Mississippi, and Alabama. It has been taken in northeast Texas also, so that its range probably extends through southern Arkansas and connects the two areas.

The woodland vole (*M. p. nemoralis*) is the largest form of the pine vole in America, and has longer and less glossy fur than the forms east of the Mississippi. Its color is deep chestnut, darker than typical *pinetorum*, but lighter than *scalopsoides* or *auricularis*. It occurs in wooded parts of southern Iowa, eastern Nebraska and Kansas, and in Missouri, northern Oklahoma, and Indian Territory.

Pine mice differ greatly in habits from the other species of *Microtus*. All the American representatives of the group have similar habits, and the injury they do to crops is little less in extent than that inflicted by meadow mice and prairie mice.

DAMAGE BY FIELD MICE.

While field mice of the various groups differ but little in the nature of their food, the circumstances under which they injure crops vary. Meadow mice invade cleanly cultivated fields only under the shelter of snow. Hence they do most damage in years of great snowfall. Although prairie mice commit greater depredations under cover of snow than in open seasons, their attacks upon crops are far less dependent upon snowfall than those of meadow mice. Pine mice work in the shelter of their own burrows; hence their injuries to plants are quite independent of the amount of snow.

DAMAGE TO MEADOWS AND PASTURES.

Complaints of damage to meadows and pastures by field mice have been increasing in recent years. Usually the injury is confined to small areas, which the animals attack from the shelter of snowdrifts or old grass. Under cover of these, the animals eat the succulent crowns of clover and other grasses; and when the snow lies for several weeks the crops over large areas are often completely ruined. Sometimes whole fields of red clover are so badly damaged by mice that they have to be replowed in the spring and planted to other crops.

Damage to permanent, or uncultivated, meadows is usually more serious, as the mice breed and multiply throughout the field and, under cover of the growing crop of leafy stubble, devour and destroy throughout the year. Occasionally, however, actual benefit may result from their thinning the grasses and stirring the soil about the roots. Thus, after the vole plague in Scotland in 1892, the farmers reported that the pastures were better than before; but the improvement by no means compensated for the losses caused by the impaired pasturage of the two preceding years.

When mice are abundant during the growing season, the quantity of grass they destroy is great, more being cut down and left upon the ground than is actually consumed. In winter hay in stacks is injured by field mice, and instances are known in which large stacks were so badly damaged that in the spring little or no salable hay remained.

DAMAGE TO GRAINS AND FORAGE.

Growing grains—wheat, oats, barley, rye, and buckwheat—are destroyed by field mice. Attacks begin with the sprouting grain, and, in the case of fall sown wheat and rye, continue during the entire winter. However, when only the blades of the plants are eaten this winter consumption has but little effect upon the amount of grain subsequently harvested. Much greater damage is done when the grain is nearly mature, as stalks are then cut down. After the grain ripens, devastation by mice continues until after harvest, when the animals attack the shocked grain and even the stacks. The total amount of injury by mice depends both on the number of the animals present and on the length of time the grain is left in shocks. In these artificial shelters mice are perfectly at home and multiply with great rapidity, so that within a few weeks a pair and their progeny may totally ruin an entire shock of wheat or oats.

As nearly all farmers know, field mice destroy corn, Kafir corn, and cane, whether stored in shock or in pile. The annual destruction both of grain and of forage throughout the country is enormous, although accurate statistics of losses are not available. Of course, not all the injury is done by short-tailed field mice. White-footed mice (*Peromyscus*), pocket mice (*Perognathus*), harvest mice (*Reithrodontomys*), and ordinary house mice (*Mus musculus*) also are concerned in the damage. Throughout the country the brown rat (*Mus norvegicus*) and in the Southwest the cotton rat (*Sigmodon*) are serious field pests. The several kinds of field mice, however, partly because of their wide distribution, but mainly because of their great abundance, are the chief offenders in northern fields.

Grain and forage in stacks are often injured by field mice. In view of the losses to which stacked and stored grain is subject, it is a question whether the farmer who hastens to market his crop is not, on the whole, a gainer over his neighbor who waits for more favorable prices.

DAMAGE TO GARDEN CROPS.

Field mice do much injury in market and other gardens, attacking planted seeds in the open garden, hotbed, or cold frame. Pine mice are the chief offenders in inclosures, sometimes working their way even into greenhouses, where they attack bulbs and tender growing plants, as well as all kinds of seeds.

Field mice injure early peas and other vegetables growing in open grounds, and pine mice often destroy potatoes in the ground. In the fall vegetables piled on the ground or stored in pits are liable to attacks. Among these are potatoes, beets, turnips, carrots, parsnips, cabbage, sweet potatoes, and especially celery. Apples, pears, and other fruits are eaten also.

In parts of eastern Maryland pine mice have recently (1907) been quite destructive to melon and cantaloupe crops. The animals destroy the seed and eat the roots of the plants during the growing season. The injury was greatest on sandy lands which had not been plowed before planting, but had been smoothed with a drag, leaving the mouse tunnels below undisturbed. In some fields seed had been planted three times, but by the middle of July all hope of a crop had been abandoned.

DAMAGE TO SMALL FRUITS.

Blackberries, raspberries, grapes, currants, gooseberries, and strawberries are often badly damaged by field mice, and when the animals are abundant whole plantations are ruined. Strawberries are especially liable to injury because of winter mulching and also because the plants themselves furnish excellent food and shelter for the animals.

Fallen leaves in autumn and snow in winter drift and collect along rows of blackberry, raspberry, gooseberry, and currant bushes and furnish cover for mice, which work along the rows and girdle the green stems; and when dead canes are left uncut and weeds are permitted to grow up among them, the resulting tangle adds much to the liability of attack. Winter mulching of small fruits also increases the danger, and if practiced the utmost care should be taken to clean surrounding areas.

DAMAGE TO NURSERY STOCK.

In many sections of the United States and southern Canada nursery stock is injured by field mice. The actual loss varies from year to year and is difficult to estimate. Occasionally the havoc has been so complete that few marketable trees remained. It was estimated that during the winter of 1901–2, nurserymen in the vicinity of Rochester, N. Y., sustained losses amounting to $100,000.[a]

Damage to standing nursery stock is done usually under cover of snow, and hence is greatest in seasons of deep snows that remain long upon the ground. In addition to girdling trees above the surface of the ground, meadow mice sometimes burrow beside the trunk and attack the roots (Pl. III, fig. 2). Pine mice usually begin their

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[a] New York Sun, April 27, 1902.

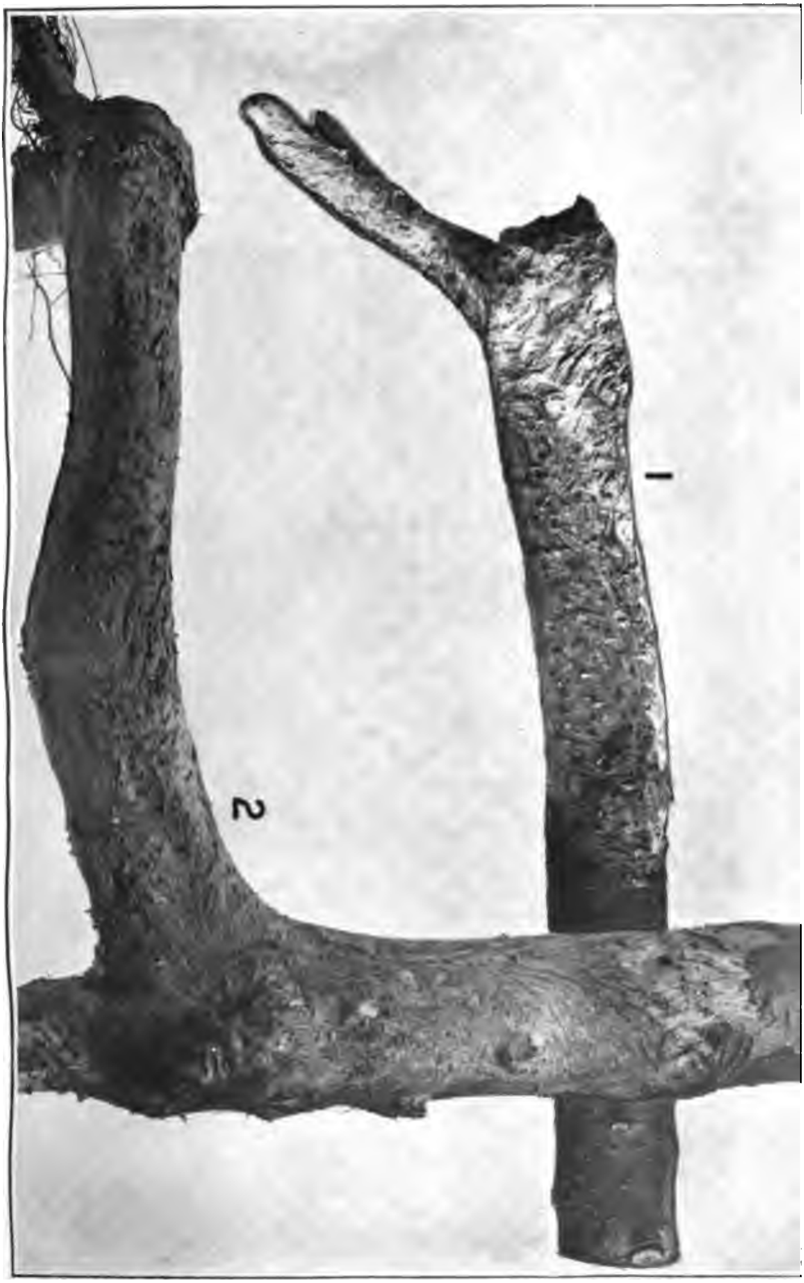
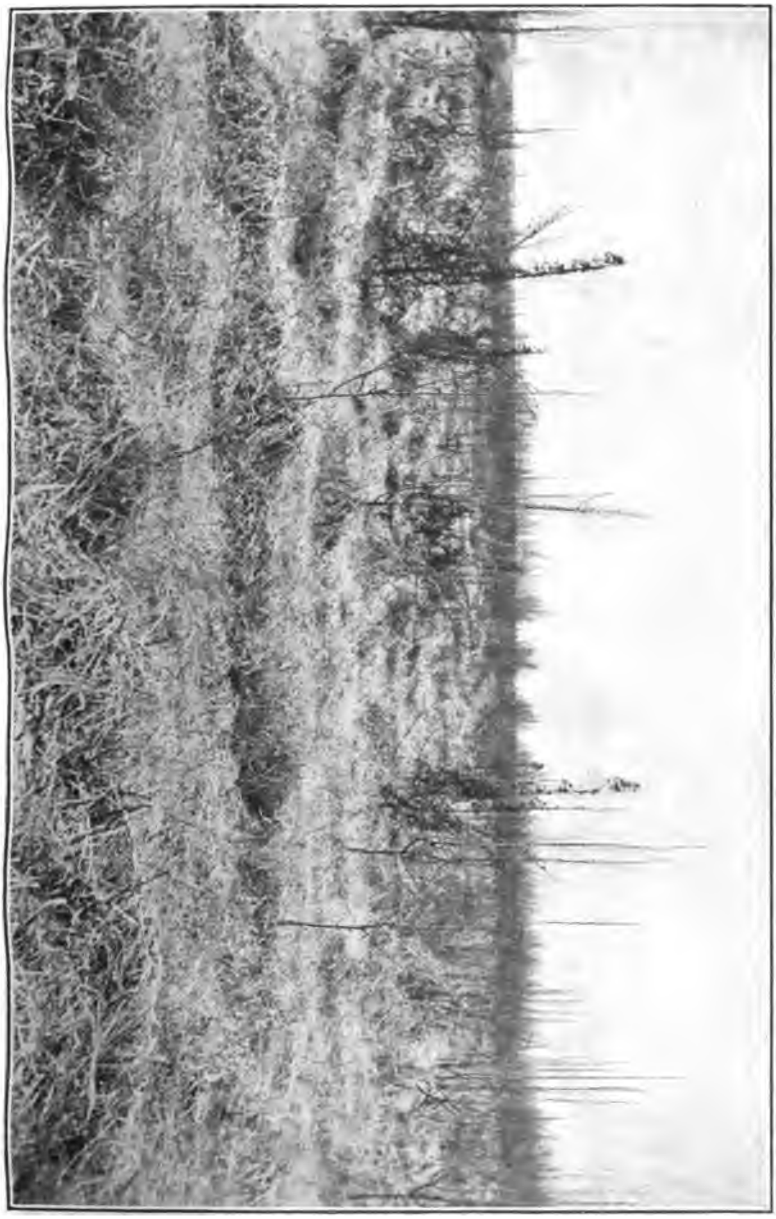


FIG. 1.—YOUNG APPLE TREE EATEN BY PINE MICE. FIG. 2.—YOUNG APPLE TREE EATEN BY MEADOW MICE.



A NEGLECTED YOUNG ORCHARD IN WINTER, WHERE MEADOW MICE RUN RIOT.

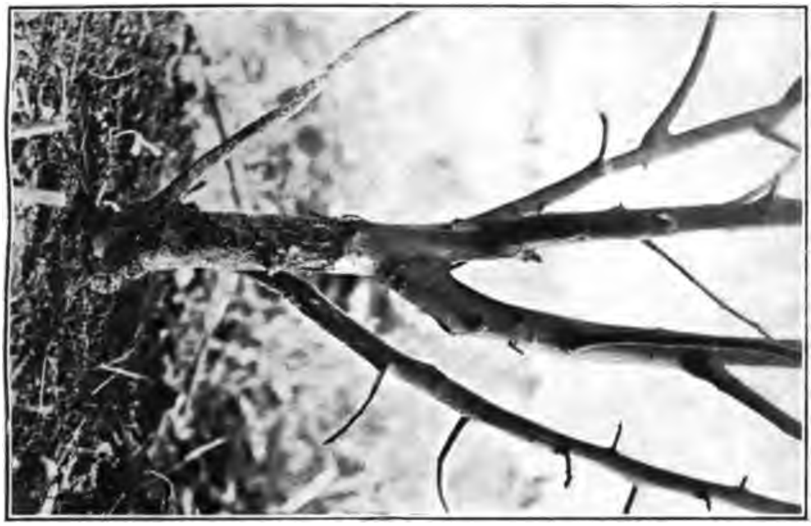


FIG. 1.—PEAR TREE INJURED BY MEADOW MICE.

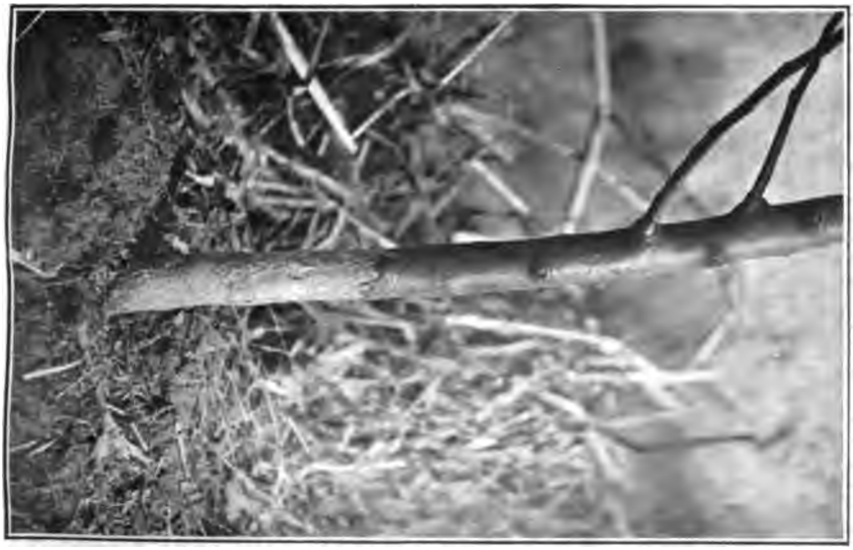


FIG. 2.—APPLE TREE INJURED BY MEADOW MICE.

attacks below the surface and except under cover of snow rarely extend them above ground. They sometimes consume the entire roots of small apple trees so that only the trunk is left (Pl. III, fig. 1). Experienced nurserymen prevent serious injury to standing stock by clean cultivation. Stock that has been taken up in the fall and " heeled in " or kept in storage pits is, however, liable to attack, especially if covered by straw, leaves, or other litter. Hence for protection from freezing a loose covering of soil is better than litter. Winter seed beds of conifers, oaks, and nut-bearing trees are often attacked by field mice and need to be carefully protected from them as well as from white-footed mice (*Peromyscus*). Small pine trees in the nursery also are liable to injury, since their low branches usually furnish cover for mice.

Among the nursery stock injured by field mice are apple, pear, quince, plum, peach, cherry, crabapple, sugar and Norway maple, chestnut, black locust, Osage orange, sassafras, alder, white ash, mountain ash, various oaks, cottonwood, willow, pine, and wild cherry trees; also blackberry, raspberry, rose, currant, and barberry bushes, as well as grape vines. In the Arnold Arboretum, Jamaica Plain, Mass., during the winter of 1903–4, meadow mice destroyed thousands of trees and shrubs, including apple, maple, sumac, barberry, buckthorn, dwarf cherry, snowball, bush honeysuckle, juniper, blueberry, dogwood, beech, and larch. Plants in nursery beds and acorns and cuttings in boxes especially were harmed.[a]

INJURY TO ORCHARDS.

Trees transplanted from the nursery into the orchard are in more danger from field mice while the outer bark is green and tender, but there are instances in which trees 5 and 6 inches in diameter have been attacked and killed by them. Most farmers are inexperienced as orchardists, and plant fruit trees only for family use. Engrossed in the production of other crops, they often neglect the orchard and permit annual grasses or weeds to grow up, which afford cover for mice. Often, too, clover or orchard grass is sown in the orchard as a covering for the ground, and the heavy growth left for winter mulch is augmented by fallen leaves. Under such conditions it is not strange that mice injure the trees. It is remarkable, indeed, that so many orchards escape injury. That they do so may in part be attributed to the fact that they are often near dwellings, where hens scratch and cats prowl.

Attacks upon orchards by mice are not always accomplished under cover of snow, nor are they confined to winter. They frequently occur in summer, often in September. During the winter of 1905–6 a small orchard of apple and pear trees near Washington, D. C., was under observation from October to April. Attacks by meadow mice began in the early fall, possibly in August. They were continued during every succeeding month, being greatest during two short periods of snow. Independent of snowfall, they were greatest in mild and least in cold weather. A few trees had no weeds or grass near the trunks, and these escaped injury. The neglected condition of this orchard appears from a photograph (Pl. IV) taken January 24, 1906. Adjoining the orchard was a tangled thicket on low, moist ground, in which meadow mice were abundant.

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[a] Boston Transcript, April 16, 1904.

On March 16, 1906, I found that of 380 apple trees, 164, or over 43 percent, were ruined, being completely girdled, some to a height of 8 to 10 inches above the ground. Thirty-six others, nearly 10 percent, were less badly injured, while 180, or 47 percent, apparently, were uninjured.[a]

Of 200 pear trees in the orchard 50 were more or less seriously damaged. The injury to these was inflicted early in the fall.

The nature of the damage to individual trees in the orchard is well shown in Plate V.

INJURY TO FOREST TREES.

As an example of the danger from field mice to which plantations of forest trees are exposed, the following is cited: In 1813 and 1814 young plantations of trees in Dean and New forests, England, were greatly damaged by mice, probably *M. agrestis*. The damage was to planted acorns, two-thirds of which were destroyed, and to holly, oak, and chestnut trees, some of which were 5 years old. Not only were the trees girdled above the surface of the ground, but often the roots also were gnawed through. The land was covered with long grass, ferns, etc., which furnished abundant shelter for voles.[b] During the winter of 1813-14 more than 30,000 mice by actual count were destroyed in Dean Forest and 11,500 in New Forest. It was calculated that the total killed by all the agencies employed was probably double these numbers. The total number of voles killed in both forests during the outbreak was estimated at 200,000.[c]

In the past, American forestry has concerned itself chiefly with efforts at conservation, but forest extension has progressed far enough to enable us to judge of the extent of injury that field mice are likely to inflict upon new plantations. The experience in the Arnold Arboretum, already referred to, is probably an example of what may be expected.

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[a] On June 22, 1907, the number of apple trees alive in this orchard was 226. The dead trees numbered 154, many of which had succumbed to their injuries during the spring of 1907. The trees were thoroughly sprayed with lime-and-sulphur wash in November, 1906, and although many meadow mice and some rabbits were present, none of the trees were attacked during the succeeding winter.

[b] Lord Glenbervie's Account, Zool. Journ., vol. I, pp. 433-444, January, 1825.

[c] Bell's History of British Quadrupeds, p. 325, 1874.

Dr. C. A. Schenck, forester of the Vanderbilt estate, Biltmore, N. C., in a recent communication to the Biological Survey, states that plantations of locust and black cherry suffer badly from the girdling of mice, "especially the locust, which are killed outright, usually the best specimens." And he adds, "Plantations of acorns, chestnuts, and hickory nuts are rendered impossible because of ravages of mice."

In our native forests the injury to young trees by mice has usually been unnoticed or disregarded; but hereafter, as more attention is given to forest extension, a corresponding increase in interest in mice as enemies of forest trees may be expected.

DAMAGE TO PARKS AND LAWNS.

Field mice destroy bulbs, perennial herbaceous plants, woody shrubs, and ornamental vines. To name all the kinds subject to attack is unnecessary, as but few are immune. The animals invade botanic gardens and public parks as well as private grounds. In the public parks of Hartford, Conn., during the winters of 1904 and 1905 much damage was done, especially to common laurel (*Kalmia latifolia*) and various thorns (*Cratægus*). Rosebushes and the crowns of hollyhocks are often attacked. Pine mice usually are responsible for the injury to bulbs—tulips, hyacinths, crocuses, etc. Often the straw or other litter used to protect tender plants furnishes shelter for the animals. Hedges, while often subject to injury from voles, also afford protection under which the animals gain access to ornamental plantations.

During the winter of 1904–5 pine mice invaded dooryards near Lanham, Md., and destroyed many plants. In one case 50 choice hyacinths and tulip bulbs in a bed were badly eaten, so that only 4 or 5 sickly plants came up in spring. In an adjoining dooryard, in the spring of 1907, the animals girdled a considerable number of young white pines (*Pinus strobus*) and ate the roots.

STUDIES IN AN ORCHARD.

In December, 1903, I examined a large orchard in Marion County, Kans., where field mice were causing much damage. As the case of this orchard is in many respects typical, details of its treatment will be given. The orchard comprised 480 acres and contained about 26,000 trees, mostly apple, eight to ten years transplanted. The trees averaged about 4 inches in diameter, but many measured 5 or 6 inches. The majority were headed low, their outer drooping branches touching the ground (Pl. VI, fig. 1). In the spring of 1903 corn had been planted by listing it in the open spaces between the rows of trees; but owing to an unusually wet summer, the crop had been abandoned, and sunflowers and other weeds and grasses had made a luxuriant growth throughout the orchard. Over much of the area, apparently, no attempt had been made to cut down the weeds; and where they had been mowed they had been raked into piles and not burned or removed.

In this neglected orchard field mice—the prairie vole—had found a congenial home. Already abundant in 1902, they bred plentifully in the open fall of that year and in the early warm spring of 1903. The ensuing moist summer also was favorable for continued reproduction, and by the fall of 1903 they were present in hordes. All the orchards of the neighborhood—a comparatively level upland prairie—had been neglected and all were invaded by mice; but the one above mentioned was the largest and most neglected, and therefore it suffered most severely. By December 18, the date of my first visit, mice had wholly or partially girdled at the surface of the ground fully 5,000 apple trees and had denuded of bark many of the low branches. The owners of the orchard, thinking that none of the trees could survive the injuries, then estimated their loss at from $25,000 to $30,000.

Examination showed that the ground everywhere was honeycombed by mouse burrows and tunnels to a depth of 3 or 4 inches, and that the surface was almost covered by a network of runways of the prairie vole. Upon digging into the burrows at the base of apple trees I found many twigs, 4 to 6 inches long, that had been entirely stripped of bark and left lying in little piles. I had no difficulty in finding where the twigs had been severed from low-growing branches and the tips of sprouts, and in distinguishing, by the smaller tooth marks, the cutting done by mice from that done by rabbits. Whether the twigs had been first stored and afterwards fed upon in cold weather I was unable to determine, for I found none with bark remaining upon them. Probably they were carried to the burrows merely for leisurely but immediate consumption.

Contrary to the usual habits of voles in our Northern States, this injury had been done during mild weather. Up to December 18 the season had been warm and open. No snow lay on the ground for more than twenty-four hours. Ordinary food, such as grass, seeds, and grain, was abundant, so that the only explanation for the injury to trees seems to be the vast numbers of voles present and their preference for a partial diet of bark.

Voles, however, were not the only animals abundant in the orchard. Rabbits, both cottontails and jacks, were there in great numbers, and

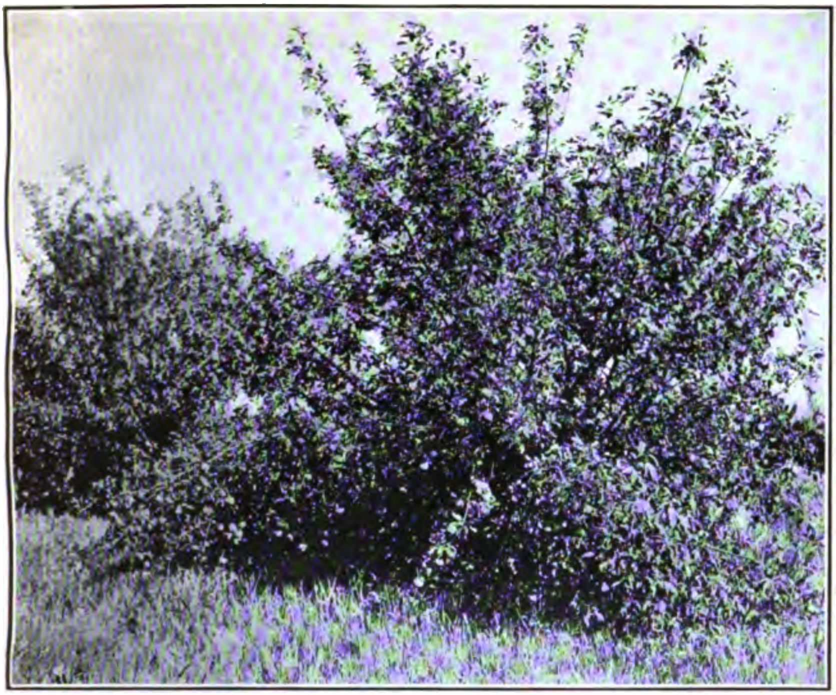


FIG. 1.—LOW-HEADED APPLE TREE IN A KANSAS ORCHARD.

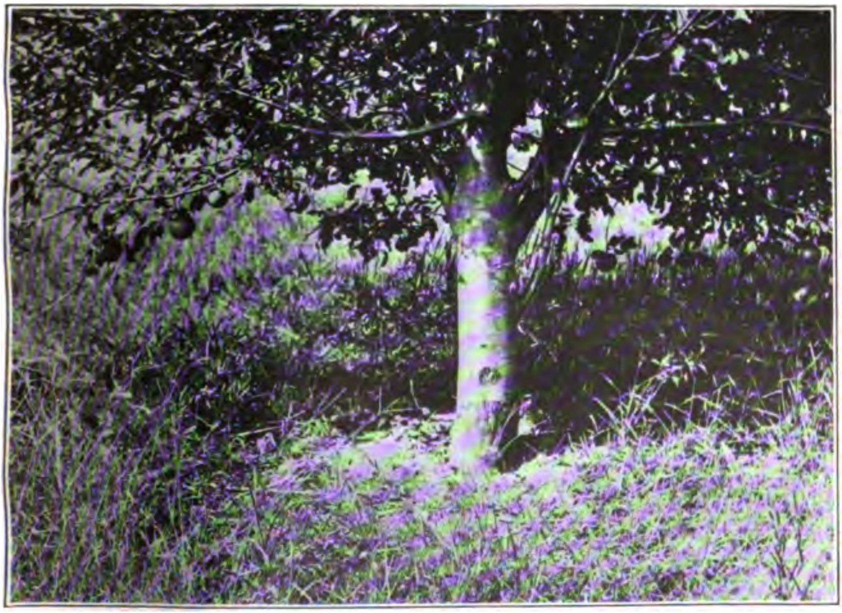


FIG. 2.—APPLE TREE RECOVERED AFTER INJURY BY MICE.

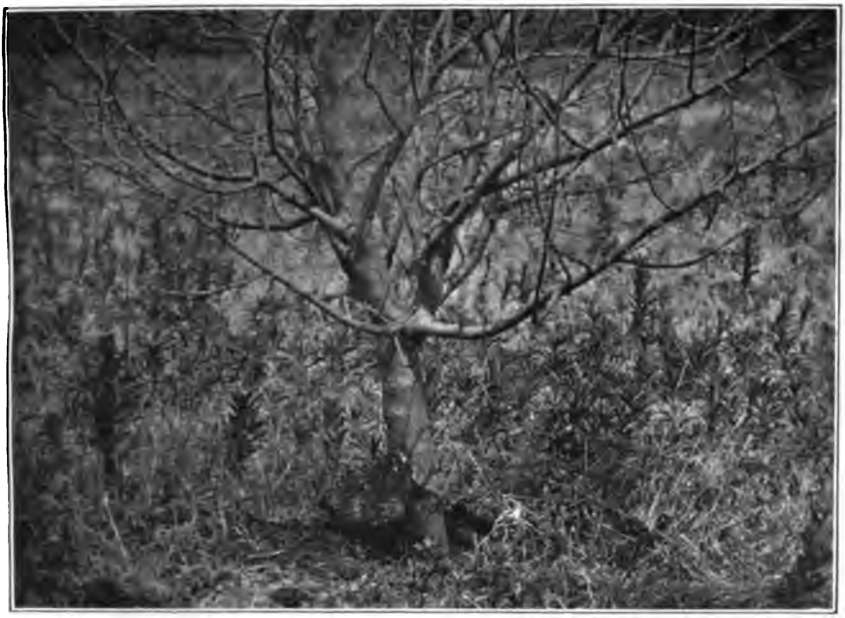


FIG. 1.—APPLE TREE KILLED BY PRAIRIE MICE.

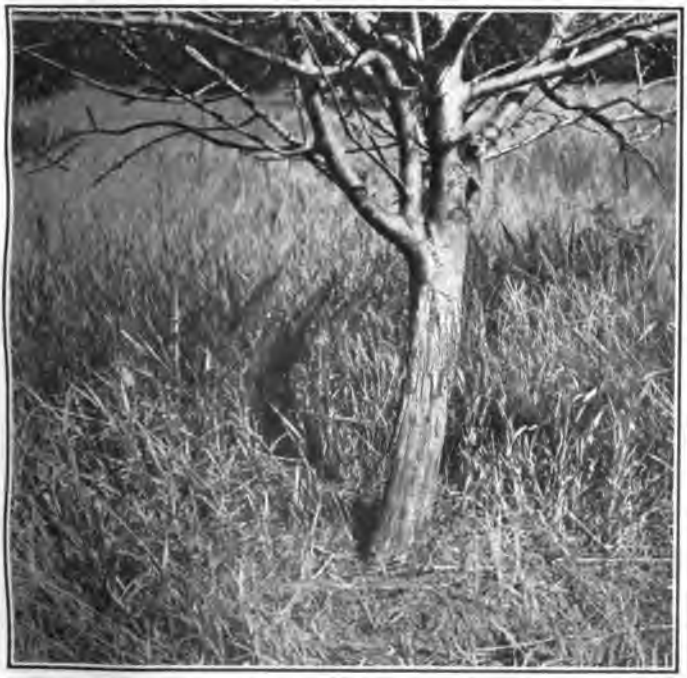
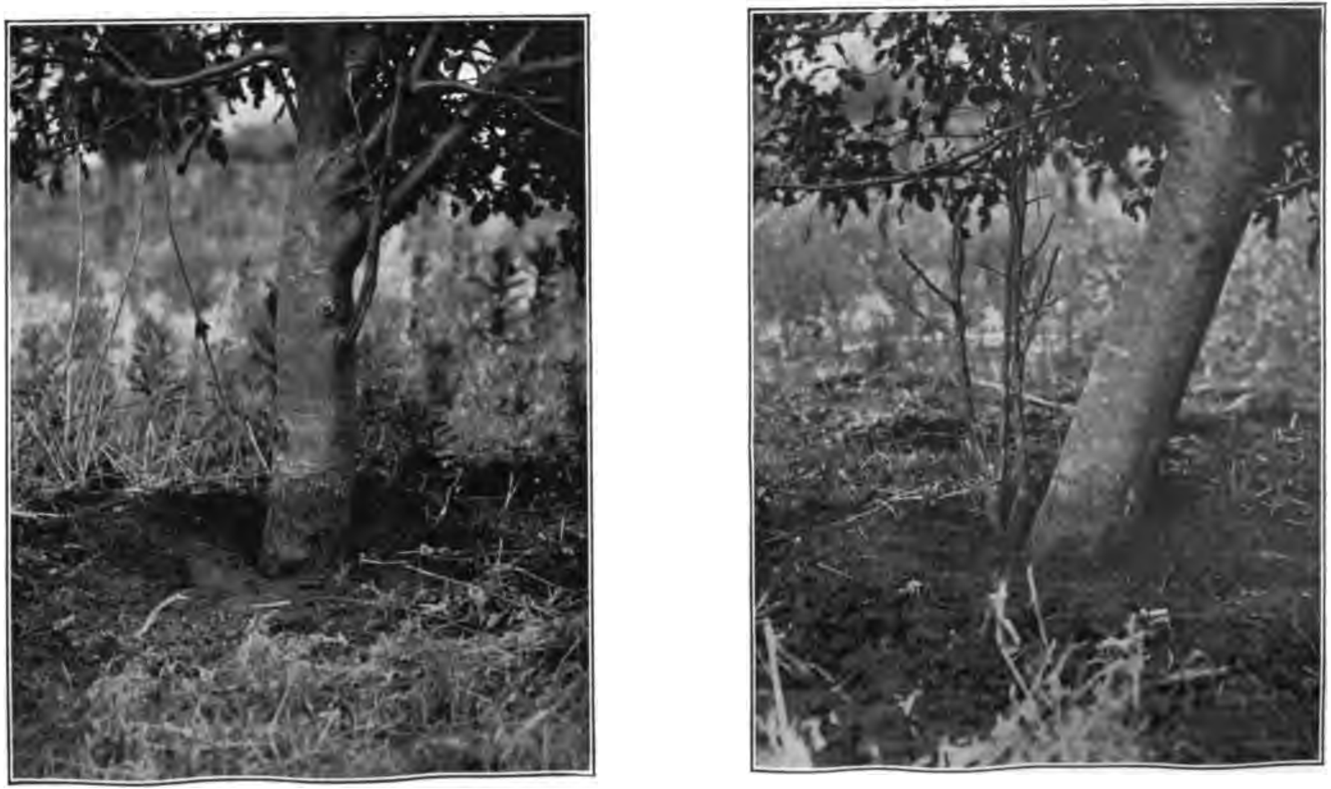


FIG. 2.—APPLE TREE KILLED BY RABBITS.



APPLE TREES 5 INCHES IN DIAMETER, GIRDLED BY PRAIRIE MICE (MICROTUS OCHROGASTER).

[Trees saved by heaping up soil about the trunks to cover the injury.]

already had begun to eat the bark on the trunks of some of the trees and on the low limbs, and to cut the tips of branches and sprouts within their reach. Later, when cold weather set in and snow covered the ground, they also seriously damaged the trees.

White-footed mice (*Peromyscus michiganensis*) were especially numerous, but stomach examinations of individuals captured revealed no evidence that they had eaten bark of trees. Skunks, short-eared owls, and marsh hawks were common, no doubt attracted to the vicinity by the abundance of mice. From the large number of partly devoured dead mice found in the burrows during poisoning operations, I had reason to think that shrews (*Blarina brevicauda*) also were abundant. Of course living voles helped to devour the dead.

Previous to my visit a force of men and boys had been employed in painting the trunks of the trees with a wash composed of soap, crude carbolic acid, and water. The efficacy of this wash as a preventive of attacks of mice or rabbits did not extend beyond a period of forty-eight hours.

On the evening of my arrival I placed wheat poisoned with strychnine at the base of about 50 apple trees. On the next morning a large number of dead voles and white-footed mice were found. So favorably were the owners of the orchard impressed by the result that a force of men was employed to distribute poisoned grain throughout the orchard.

The poisoning operations in this orchard occupied several weeks, and by January, 1904, the mice apparently had been exterminated. Rabbits, however, continued to give trouble, and the campaign against them was continued for some time longer, with final success.

As a treatment for the trees injured by mice, I recommended the immediate covering of the wounds by mounds of soil heaped up around the trunks. The plan was adopted with highly satisfactory results. New bark grew wherever the cambium layer was not eaten completely through, and a great majority of the trees recovered. (Pl. VI, fig. 2.) Had their trunks been left exposed to the sun and winds of spring and summer most of them would have died. The number of trees actually killed by mice was not very great, although the growth of many was seriously checked.

Although at first the damages from mice seemed far more extensive than those from rabbits, the ultimate losses from them probably were less. The wounds from rabbits were too high up to be successfully covered with soil, and no remedy other than wrapping with paper was tried. The difference in the character of the injuries by these animals is well illustrated by Plate VII, which shows two dead trees—one killed by mice and the other by rabbits. Plate VIII and Plate VI, figure 2, illustrate injured trees in the same orchard which have fully recovered.

The following winter, 1904–5, mice and rabbits were again abundant in the orchard, having come in from adjacent territory. The experiences of the preceding winter were repeated, except that cover for mice was less dense and the campaign against them began much earlier in the season.

During the two winters named, many other orchards throughout eastern Kansas were seriously injured by field mice. As a rule no preventive measures were used, and the total losses were enormous.

THE RELATION OF FIELD MICE TO THE FARMER.

In 1886 the Biological Survey sent out a circular letter of inquiry about damages to crops by mammals.[a] A great many replies from widely scattered places were received. The replies relating to field mice show that these animals everywhere are regarded as a pest.

The following extracts from letters on file in the office of the Bureau of Biological Survey are here presented to show not only how great is the amount of injury from field mice in certain localities, but to give an idea of the wide area over which losses are sustained.

REPORTS FROM FARMERS AND OTHERS.

Field mice are very injurious to clover fields. The injury is done by eating the roots when the ground is covered with snow. The loss is serious. They are injurious to fruit trees and yellow locust and Osage orange. They girdle them beneath the surface of the ground during deep snows. They destroy apple and pear trees, but rarely hurt peach and cherry.

—Gap, Lancaster County, Pa., Nov., 1886.

Field mice injure pastures and meadows by burrowing under grass roots and destroying them. There were more last summer than for years, I think, owing to the destruction of their natural enemies.

—Eastbrook, Lawrence County, Pa., Feb., 1887.

Meadow mice are very destructive to grain, grapes, and trees. This fall (November, 1886) three or four years ago, the fields were swarming with them. I went out with my little boy and we killed 56 in an orchard in less than two hours. In going half a mile from the station the dog picked up 15. They ruined several hundred fine apple trees for me, some of them several inches in diameter. Many thousand trees were ruined in this country. They prefer apple to plum or peach bark. —Huron, Mich., Nov., 1886.

This has been a periodical year for their invasions and the damage has been great in many fields and meadows, particularly potato fields, which have been badly damaged where the surface was grassy. They injure to a slight extent cabbage buried in the ground. Clover fields and wheat have also been damaged. They do great injury to cornfields, eating the grain and even climbing up the stalk to the ears. All kinds of vegetables are eaten. Pastures are devastated for rods where the grass is high enough to hide the mice. Other invasions occurred in 1883 and 1888. Fruit trees are not injured except in cases where there is straw or other litter; then the trees are girdled by gnawing.

—Camp Point, Adams County, Ill., Nov., 1889.

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[a] Circular No. 3, On the Economic Relations of Mammals, 1886.

Meadow mice attack almost every tree and shrub. They girdle about everything, even rosebushes, blackberry, and raspberry bushes. I saw a willow hedge yesterday (April 8, 1889), 2 years old, with nearly every stalk girdled to 6 or 8 inches above the ground. They injure pastures and meadows and destroy root crops placed in heaps. —Rochester, Mich., Apr., 1889.

Meadow mice destroy many trees and vines. The natural enemies of these mice are as much of a nuisance as the mice themselves.

—Frankfort, Mich., 1888.

Orchards here have suffered this winter from the depredations of the meadow mouse. I presume thousands of trees have been badly gnawed in this town alone. Still the war of extermination goes on against hawks and owls.

—Hammondville, N. Y., Apr., 1887.

They eat potatoes in the ground and corn in the shock. Do considerable damage to potatoes, sweet potatoes, and peanuts. —Eubank, Ky., 1887.

Field mice destroy wheat by cutting off the stalks. Sometimes the loss is serious. They are also injurious to pastures and meadows.

—French Creek, W. Va., July, 1888.

Meadow mice sometimes injure meadows. They often do serious damage to trees and shrubs. Some seasons acres of young forest trees are barked. Maple and apple suffer the oftenest. —La Crescent, Minn., Nov., 1886.

Meadow moles (voles) are present in greater numbers than ever observed before. These voles have totally ruined a great many clover meadows, strawberry patches, and pastures that were not eaten close. They have girdled hedges until they can not live, and I noticed one place where a white ash tree, 4 inches in diameter, was stripped of bark for 6 inches above the ground. They have dug into pits containing turnips and beets and devoured them completely. They promise to be with us next season in untold millions. Their presence is the more noticeable as eighteen months ago I tried to get a single specimen to send to the Department of Agriculture for identification and could not.

—Cardington, Ohio, Feb., 1890.

Field mice injure pastures and meadows by eating off the roots during winter. We are now suffering, and have been for two years, from invasions of field mice. We suffer a material loss by having the bark gnawed from most kinds of fruit trees by them during the winter. —Gansevoort, N. Y., Feb., 1888.

Our country place in Maine is being overrun with mice, which nest in the ground and destroy all the plants by eating the roots or tops of the plants as soon as they appear. —Letter from Baltimore, Md., May 16, 1904.

The summer and winter of 1883 this county was overrun with meadow mice. They destroyed thousands of apple trees, besides lots of young forest trees. Besides girdling trees, voles do meadow lands a good deal of injury by eating off the crowns of the clover plants. Three hundred dollars would not repair the damage done to an orchard near the station. In 1863 trees 6 inches in diameter were stripped of bark clear up to the limbs 4 or 5 feet from the roots.

—Huron County, Mich., Oct., 1886.

The meadow mouse is very prolific. Its presence varies at periods from a few to countless numbers. Long droughts and inclement winters as well as natural enemies probably affect their numbers.

—Kansasville, Wis., Sept., 1888.

They damage hay by cutting the grass into lengths the size of toothpicks.

—Tower, Minn., June, 1895.

Mice eat celery put up in the garden. They also eat roots of grass if there is a heavy snow on the ground during the winter.

—Lewisburg, Union County, Pa., Dec., 1886.

Mice often cause serious trouble in the winter season by girdling fruit trees, especially apple and peach trees. They commit depredations on buckwheat fields. —Milan, Bradford County, Pa., 1888.

Our fields are subject to invasions of meadow mice during the winter when mulch is on them. A thousand of the mice wintered 1885–86 on a 2-acre strawberry patch. They eat the bark of trees when straw is placed about them or snow is on the ground. —Mexico, N. Y., 1886.

Meadow mice injure dams, banks, drains, and embankments.

—Gilbertville, N. Y., 1887.

Meadow mice injure vegetables; they are especially fond of beets. They injure meadows quite seriously when numerous by feeding on grass roots. They were extremely numerous in 1885, and ate potatoes in the hills.

—Little Valley, N. Y., 1887.

In some cases I have found a shock of corn with half the corn consumed by meadow mice. —Caldwell, N. J., Nov. 1, 1886.

The fields are full of mice. They are about the ears of standing corn, while that on the ground is mostly eaten. This is surely an invasion of mice. I can account for it only because last winter was so mild that all of them survived.

—Fairfield, Iowa, Nov., 1889.

Meadow mice are very destructive to the harvest fields, particularly in the shocks. They bite the ears of wheat and cut the twine bands off the sheaves. They gnaw young fruit trees in winter, if manure or straw is left close around the stem, and they kill the trees. —Willows, Griggs County, Dak., Dec., 1886.

Field voles eat wheat, rye, and other cereals, both green and when matured, and carry green grain as well as matured kernels into their burrows. They sometimes carry a half bushel of grain into a single hole. They damage fodder by cutting it. —North Topeka, Kans., May, 1890.

In the summer of 1884 we had an invasion of meadow mice [probably *M. townsendi*], and they did much damage. They destroyed seeds in the garden and ate growing wheat and oats in the spring, sometimes nearly destroying entire fields. They played havoc with the early peas and destroyed carrots and parsnips in the fall. The summer was unusually wet. The next summer was dry, and the mice disappeared. This is the only mouse year we have ever had here. During the year nearly all the cats died, apparently from eating the mice. They caught and ate them freely and were all affected alike. Some vomited more freely than others; they got puny, refused to eat, and died. Since the "mouse year" cats are themselves again.

—Aumsville, Oreg., Dec., 1886.

The bob-tailed mouse is a pest here, eating all kinds of bulbs, lilies, tulips, potatoes, etc. —Centerville, Mo., 1887.

Meadow mice ruined nearly the entire crop of clover in the winter of 1884–85.

—Wakeman, Ohio, 1886.

We are troubled with meadow voles. When we have much snow in winter they are very plentiful the next summer. Winter thaws, which leave the fields bare of snow, destroy them. They destroy fruit trees by gnawing the bark under the snow. I think they will eat the bark from any kind of young trees. The damage is serious. —Montpelier, Vt., Nov., 1886.

Voles sometimes gnaw young apple and pear trees, mostly in winter; in summer also where red clover grows about the trees. The loss is serious.
—Salem, Ohio, 1886.

Meadow mice are injurious to meadows and pastures by cutting the sod in winter. We had an invasion of them in the winter of 1864, when they killed grape vines, raspberries, and crab-apple trees 5 inches in diameter.
—Stoughton, Wis., 1887.

Field mice are destructive to grain crops. Their depredations are mostly confined to the consumption of grain, but the injury by them depends upon the nut crop; if this is plentiful they do not disturb grain, or corn chiefly, but if there is a scarcity of nuts, they make incursions on the fields of corn, doing considerable damage. —Columbia, Conn., Sept., 1887.

The majority of the preceding reports refer to the common meadow mouse (*M. pennsylvanicus*) and its subspecies, but some of them from the Middle West undoubtedly include references to the prairie vole (*M. ochrogaster*), which is more numerous there. Most of the destruction to potatoes and stored vegetables may be attributed to pine mice.

REPORTS FROM NURSERYMEN AND ORCHARDISTS.

Early in March, 1906, a circular letter of inquiry asking for information in regard to damages by field mice was sent to more than a thousand representative nurserymen and fruit growers in the United States and southern Canada. Up to April 10, 1906, replies returned number 520, of which a summary is presented in tabular form.

Damages by field mice, as reported by nurserymen and fruit growers.

State or province	Number of circulars sent.	Number of replies received.	Mice abundant.	Mice not abundant.	Mice absent.	Damage by mice serious.	Damage not serious.	Damage none.	Number who make estimates.	Total of damage estimates.
Maine	8	4	2	2	......	2	1	1	2	$125
Mew Hampshire	11	7	5	2	......	4	3	......	2	100
Vermont	6	2	1	1	......	......	2	......	......	......
Massachusetts	40	23	11	12	......	7	10	6	7	865
Rhode Island	6	4	......	1	3	......	1	3	......	......
Connecticut	22	11	7	4	......	3	6	2	4	460
New York	85	34	24	9	1	20	7	7	16	8,275
New Jersey	23	12	6	6	......	3	8	1	4	750
Pennsylvania	37	27	22	5	......	13	11	3	15	3,100
Delaware	10	3	......	3	......	......	2	1	......	......
Maryland	20	12	6	6	......	3	4	5	2	35
Virginia	12	3	1	2	......	......	3	......	......	......
West Virginia	9	6	2	4	......	1	2	3	1	350
North Carolina	16	10	6	4	......	4	2	4	1	3,000
South Carolina	3	1	......	......	1	......	......	1	......	......
Georgia	16	8	......	2	6	......	1	7	......	......
Florida	6	5	[a]3	2	......	......	......	5	......	......
Alabama	22	9	......	5	4	......	1	8	......	......
Mississippi	9	3	......	1	2	......	......	3	......	......
Tennessee	18	7	2	5	......	......	2	5	1	25
Kentucky	30	18	3	15	......	2	8	8	1	75

[a] Probably not *Microtus*.

Damages by field mice, as reported by nurserymen and fruit growers—Cont'd.

State or province.	Number of circulars sent.	Number of replies received.	Mice abundant.	Mice not abundant.	Mice absent.	Damage by mice serious.	Damage not serious.	Damage done.	Number who make estimates.	Total of damage estimates.
Ohio	51	24	13	11	......	6	12	6	5	$700
Indiana	40	20	7	13	......	5	9	6	......	......
Illinois	56	29	19	8	2	14	8	7	12	4,800
Michigan	43	19	13	6	......	7	8	4	5	1,400
Wisconsin	28	13	9	4	......	6	4	3	6	6,825
Minnesota	27	22	17	5	......	13	8	1	13	4,685
Iowa	49	26	22	4	......	16	7	3	4	2,500
Missouri	38	25	16	9	......	13	4	8	7	4,150
Arkansas	16	7	2	3	2	......	2	5	......	......
Louisiana	10	6	......	[a]2	4	......	1	5	......	......
Texas	18	10	[a]3	6	1	......	2	8	......	......
Oklahoma	14	6	......	6	......	......	6	......	......	......
Indian Territory	5	3	......	3	......	......	......	3	......	......
Kansas	46	27	12	15	......	8	9	10	9	57,400
Nebraska	32	20	7	13	......	6	7	7	3	350
South Dakota	16	7	2	5	......	2	3	2	......	......
North Dakota	6	5	2	2	1	2	1	2	1	100
Montana	11	8	3	......	......	2	1	......	1	500
Wyoming	1	1	1	......	......	......	......	1	......	......
Colorado	10	3	1	1	1	......	......	3	......	......
New Mexico	4	1	......	......	1	......	......	1	......	......
Arizona	1	1	......	......	1	......	......	1	......	......
Utah	5	3	2	1	......	1	2	......	......	......
Nevada	0	0	......	......	......	......	......	......	......	......
California	18	10	2	3	5	1	1	8	......	......
Oregon	12	7	4	2	1	1	1	5	......	......
Idaho	8	4	3	1	......	1	2	1	1	50
Washington	9	4	......	4	......	1	3	......	2	75
Ontario	17	4	4	......	......	4	......	......	3	6,500
Quebec	2	1	1	......	......	1	......	......	......	......
Total	1,003	520	266	218	36	172	175	173	129	107,195

[a] Probably not *Microtus*.

Some comments on the above table are necessary. In reporting the abundance of mice nearly all the replies refer to present conditions. In many places where the animals are not now common they have been numerous in past years. In reporting damages many correspondents gave only personal experience, but did not answer the question as to damages in the neighborhood. Few of the persons who had sustained serious damages were able to estimate the amount of the losses, while many whose losses were slight made such estimates.

It will be noticed that in the South the injury from field mice is not serious, and that in the far West mice are troublesome in fewer localities than in the northern part of the country east of the Mississippi River.

Extracts from replies to the circular are here presented:

> Field mice are abundant here. They have done me a great deal of damage during the past year, principally on overgrown stock that I have not cultivated, allowing grass to grow around the trees. They were also very destructive to a lot of young date palms (*Phœnix canariensis*) grown close together in a bed.
>
> —West Berkeley, Cal.

> Field mice are abundant here. We lost about 200 fruit trees from their attacks in 1903. Other orchards and nurseries in this section have been badly injured.
>
> —Carlton, Mont.

Field mice are abundant in this vicinity, and in the winter of 1904–5 did much damage to orchards. In neighboring orchards, where girdling is claimed to be done by rabbits, I find that in five-sixths of the cases the injury is done by mice. —Cokato, Minn.

We lost 2,000 trees in our orchards, not all killed—actual loss, about $4,000. —Topeka, Kans.

Mice are abundant here this winter, and have girdled 5,000 trees in the nursery. —Moundsville, W. Va.

Field mice are abundant in North Carolina. On account of the general lack of snow in the vicinity of Raleigh they have not done serious damage to trees, but are very troublesome in gardens. The general observer charges moles with all the damage, but I have found that the mice, following in the mole runs, are the most serious enemies. Following under the sweet-potato ridges they gnaw the potatoes and do a great deal of damage. By using carbon bisulphid in the mole runs I destroyed more mice than moles, and became satisfied that the vegetable eating was mainly, if not entirely, done by the mice [pine mice]. —Raleigh, N. C.

In the winter of 1904–5 my loss in the peach orchard from mice was fully 10 per cent of the 1-year-old trees and 5 per cent of the 2-year-old. One 2-year-old peach orchard having turnips only on the ground was badly injured where snow was drifted. Another orchard in rather grassy corn stubble was injured in the same way. Peach seedlings in the nursery were also badly injured. —Aspers, Adams County, Pa.

Young trees and nursery stock were damaged by mice in 1904–5 when the snow was deep. It is difficult to protect nursery stock. The common skunk destroys field mice, and protecting the skunk is the best preventive of injury of which I know. —Collinsville, Hartford County, Conn.

Mice become worse every year, and its seems impossible to prevent damage now. This year, while there has been but little snow, they have damaged many trees. I have had 150 trees killed by mice in my orchard of 120 acres. They eat the bark from 8 inches below the surface of the ground to 12 or 15 inches above the ground. —Council Grove, Morris County, Kans.

A lot of the trees heeled in the ground over winter and covered heavily with leaves were damaged by mice. —Versailles, Ky.

During the winter of 1903–4 we had about 50 trees girdled in the orchard. Field mice seem to come as a scourge periodically. I can remember of from four to five seasons out of the past twenty-five when the pest was very, very numerous here. It seems almost incredible how all of a sudden they come and then seemingly mysteriously disappear. The country seems now to be almost free of them. —Center Point, Iowa.

Considerable damage has been done in the nursery, particularly to seeds of trees and shrubs, and also in girdling young trees under heavy snow. The mice [pine mice] work under mulching on trees and, in mole runs, on seeds and roots of some plants. —Saginaw, N. C.

No injury was noticed this open winter, but last year they girdled many young apple trees, both in the nursery rows and when heeled in.

Some few years ago this whole section suffered untold mischief by an unusual incursion of short-tailed field mice. They seemed to be everywhere, especially on roadsides and under hedges. While the snow lay deep they ate the bark from the roots of apple, locust, and some other trees, including the Osage orange.

This eating was always below the snow line or under cover of litter of any sort that hid the animals from the eyes of hawks and owls. These and foxes are their natural enemies.

The greatest absolute loss that season was in the destruction of red clover (*Trifolium pratense*). Many fields that went into winter with a beautiful aftermath of clover and other grasses came out in the spring bare of any profitable cover and had to be replowed, the clover roots having all been eaten out.

The favorite dainty with the mice is celery, when it is trenched in and covered with fodder. —Colora, Cecil County, Md.

Field mice are abundant here. While I have personally had no losses of trees from them, very many orchards and nurseries in this vicinity have been nearly ruined, especially where they were neglected and grass and weeds were permitted to grow. I prevent loss by thorough cultivation and by mounding up soil at the base of the trees late in the fall. —Boone, Boone County, Iowa.

I had perhaps 10,000 trees destroyed by mice and rabbits during the past five years, mostly by mice, in 1904 and 1905. Loss, $2,000. —Twin Bluffs, Wis.

Mice are abundant here. We have suffered no damage, but some young orchards have been completely ruined. They were left with quite a mulching of grass and cover. This made a harbor for the mice, and they girdled nearly all of the trees. —Oakland, Kans.

We lost $2,000 worth of nursery stock in 1904 and 1905.
—Rochester, N. Y.

We have a few thousand nursery trees destroyed by them each season.
—Charles City, Iowa.

Field mice abundant. My nurseries have been damaged to a great extent, especially last year during heavy snow. —Ellisville, Mo.

During the winter of 1903–4 mice were very abundant throughout the valley and, indeed, in most of the State. The damage to nurseries and orchards was about 25 per cent. Shade trees, as well as apple, were injured. The following summer the mice were exceedingly abundant in clover fields. Early in the spring they greatly disfigured lawns in the city and in the cemetery by burrowing on the surface of the ground under the snow. [The species in the valley is *M. pennsylvanicus modestus*.] —Bozeman, Mont.

Ten years ago we scarcely noticed any damage from mice. Some six years ago they began doing more or less damage and became very troublesome in the winter of 1903–4. They mowed off our two and three year old evergreens by the thousands, so that we had to rake over the beds before counting out trees to ship. We had piles of small trees the size of haycocks. I can not tell the money value, but think it much higher than I put it ($2,000).

I laid the trouble in this section to hunters. Hawks, owls, minks, skunks, etc., used to be very plenty, but they have nearly all been killed. Their principal food is mice. A short-eared owl wintered near our sheds in an evergreen, and you could hardly believe the piles of mice skins under that tree in spring.

Two years ago a pair of weasels took up their abode in our tree cellar, breeding there last year. They kept most of the mice killed off. In the summer we saw the old one quite often carrying mice to its young from outside the shed. * * * This winter has been very mild, with no snow. Mice have been plenty in meadows, but grass kept green and tender, and they did our nurseries little damage. —Waukegan, Ill.

ECONOMIC STATUS OF FIELD MICE.

The foregoing testimony as to the ravages of field mice sufficiently attests their noxious character. The extent to which they are beneficial to the farmer may be stated in few words. The upturning of the soil by gophers, ground squirrels, moles, earthworms, and various insects is an important part of its preparation for man's use, and field mice contribute to the work. In addition, mice diminish the number of weeds by eating the seeds and, possibly, occasionally devouring the roots.

The character of the vegetable matter eaten by field mice depends entirely upon the environment. If the animals live in swamps where rushes, sedges, and grasses useless to agriculture abound, their diet is confined to these, and the naturalist who investigates their food only in such surroundings may fall into the error of concluding that they are not injurious. But field mice at all times show a decided preference for cultivated plants and grains, if accessible, and in winter seek diligently for succulent roots and the green bark of trees.

REPRESSION OF FIELD MICE—NATURAL AGENCIES.

In view of their wide distribution and the nature of their habitats, the complete extermination of field mice is impossible. It is, however, entirely practicable to so reduce their numbers that crops shall be safe from serious attack. Before describing the methods which the farmer may use to destroy the animals, it is important to consider the natural agencies which aid in their repression.

CLIMATIC INFLUENCES.

Climatic conditions so strongly influence the natural increase of field mice that an understanding of their relation to such increase is important. It has been often noticed that the periods of greatest abundance of voles follow one or more open, warm winters succeeded by wet summers. If at the same time food—particularly grain—is abundant, the most favorable conditions for the increase of the animals are present, and the maximum number of young at a birth, as well as the maximum number of litters, are brought forth. When grain is abundant the young of some species are said to begin to reproduce when only 2 months old.

The continuance of favorable conditions for two or more years is sure to be followed by an enormous increase of field mice, with serious injury to crops.

Very cold winters without snow and summers of long droughts are unfavorable to the increase of field mice. Occasionally a severe frost following a heavy downpour of rain destroys nearly all field mice over large areas.

EPIDEMIC DISEASES.

Excessive multiplication of any mammal to the point of overcrowding is sure to be followed sooner or later by a fatal epidemic. Numerous instances of the prevalence of such diseases among rodents are known, and several of the historic mouse plagues were terminated by them. So complete was the destruction that several years of almost total absence of mice followed.

NATURAL ENEMIES OF FIELD MICE.

Prominent among the recognized causes for the great increase of rodent pests in recent years is the persistent destruction of the birds, mammals, and snakes that habitually prey upon them. Warfare against the natural enemies of noxious rodents is not confined to America. In the British Islands and on the Continent gamekeepers have systematically killed foxes, weasels, stoats, hawks, and owls, on the plea that they destroy game, and even farmers have joined in the warfare against the so-called "vermin." In America the same mistaken sentiment exists, and too often has led to ill-advised legislation against mammals and birds that are beneficial to the farmer. Wise measures for game protection can not be too highly commended, but ignorance of the true relations of animals and birds of prey to game is widespread even among lawmakers and sportsmen's clubs.

One of the most common mistakes made by sportsmen in the supposed interests of game protection is the offer of prizes for the destruction of alleged "game-destroying" mammals and birds. In one instance nine competitors for a club's prizes destroyed during twelve months 184 weasels, 48 foxes, 54 minks, 343 skunks, 15 great horned owls, 6 "common owls," and 148 hawks. The fact that only 21 owls were killed in an entire year by nine men trying for a record reveals a scarcity of these useful birds that is not complimentary to the intelligence of the community. The large number of skunks killed indicates ignorance or disregard of the usefulness of that animal in destroying insects and mice. Apparently, too, there was no discrimination as to the species of hawks destroyed, and it is probably safe to say that field mice in a single year have damaged the farmers of the region concerned a hundredfold more than the value of all the game and poultry saved through the offer of prizes.

The evidence presented to a committee of the British Board of Agriculture, who were investigating the Scottish vole plague of 1892, showed conclusively that in the affected district before the outbreak carnivorous animals and birds had been very scarce. The committee in their report emphasized the importance of protecting the birds, whose absence in the district in question was regarded as an important cause of the enormous multiplication of voles.

The chief natural enemies of field mice are (1) mammals, wild and domestic, (2) birds, and (3) snakes.

MAMMALS THAT DESTROY FIELD MICE.

WILD MAMMALS.

Among the wild mammals of the United States known to feed upon field mice are wolves, lynxes, foxes, badgers, raccoons, opossums, skunks, weasels, and shrews. A few of these feed upon mice habitually, and this habit, combined with their well-known service in destroying insects, compensates in great measure for the injuries they inflict in other ways.

Skunks are efficient in the destruction of mice and rats. The larger skunks (*Mephitis*), with about 17 species and subspecies, are distributed over most of the territory occupied by field mice. Their chief food is insects, but mice are second in importance on the bill of fare. Skunks not only search woods and meadows for mice but often come about barns and outbuildings in quest of the common mouse (*Mus musculus*) and brown rat (*Mus norvegicus*). While it is true that skunks sometimes destroy poultry, they do so much less frequently than is generally supposed. Comparatively few skunks learn to kill chickens, the habit being characteristic of the individual rather than of the species.

Of 36 skunks of the genus *Mephitis* whose stomachs were examined by the Biological Survey, two only, both captured in poultry houses, had eaten domestic fowls. There was no evidence that any of the 36 had destroyed game or small birds. The food consisted principally of beetles, grasshoppers, cicadas, crickets, rats, mice, and lizards. On account of their usefulness in destroying noxious insects and rodents, skunks deserve even more than the partial protection now afforded them by the laws of several States.

The habits of the little spotted skunks (*Spilogale*) are similar to those of the larger species. Like them, they are useful because they destroy insects and mice. Occasionally individuals learn to destroy domestic fowls, but the habit is even rarer than with the large skunks. As persistent and successful mousers about farm premises, they are unequaled and should be protected, the death penalty being reserved solely for the individuals that attack poultry.

The white-backed skunks (*Conepatus*) live in the South, mostly out of the range of field mice. They destroy many other kinds of rats and mice.

The mink (*Lutreola*) feeds commonly upon fish and other aquatic animals, but sometimes raids poultry kept near streams. It destroys meadow mice as well as other small rodents. The fur is in such demand, however, that minks are not likely to become sufficiently numerous to have much effect, good or bad, upon the interests of the farmer.

The various species of weasels and wild ferrets are persistent destroyers of meadow mice. The smaller weasels easily traverse the surface runways of the larger species of *Microtus* and even follow them into underground burrows. The larger weasels feed upon pocket gophers, prairie dogs, ground squirrels, and various kinds of mice and rats. While occasionally they capture game or song birds, as well as poultry, their principal food consists of injurious rodents.

The small American weasels, like European species, have an evil reputation among game preservers and farmers, who assert that weasels destroy the eggs and young of game birds, as well as young chickens and other fowls. However, stomach examinations, supplemented by careful field observations, show that small mammals form the principal food of weasels. Among their prey are cottontail rabbits, little chief hares (*Ochotona*), prairie dogs, ground squirrels, wood rats, field mice, and the house mouse and brown rat.

A recent advance in the price of weasel skins in white, or winter, pelage has already caused a marked scarcity of these animals in some of the Northern States. The present abundance of meadow mice in the same States is attributable partly to the destruction of weasels. A correspondent in Minnesota, in a letter dated April 14, 1906, states that field mice were very abundant in his neighborhood during the preceding winter and caused much damage in orchards and nurseries. He adds: "The animals have never been so numerous here as during the last two years. I think weasels used to keep mice in check, but the high price of fur has made them very scarce."

Badgers, when not employed in unearthing larger rodents, devote much time and labor to digging out field mice. One will patiently excavate every burrow on an acre or more of ground, and, besides the litters of young, evidently get a large share of the old mice. Badgers have been caught with their intestines full of pellets of fur and bones of *Microtus*. Nevertheless, while doing almost no harm and while in general highly beneficial, badgers are destroyed almost everywhere, partly for sport, partly because on rare occasions one raids an unprotected chicken coop.

Foxes destroy many field mice and other rodents as well as many insects, especially grasshoppers, and thus do much to compensate for the poultry and game they kill. Although reliable testimony to the destruction of domestic fowls by the red fox (*Vulpes fulva*) is not wanting, the habit is by no means common, as is shown by the contents of stomachs examined by the Biological Survey. In three cases remains of the Gambel partridge were found and in one other a small bird. On the other hand, harmful rodents, including field mice, were found in over 20 stomachs. Besides these, a mole, a lizard, grass, corn, blueberries, and cultivated grapes show a somewhat miscellaneous diet. A writer in Forest and Stream states that in the stomach of a gray fox (*Urocyon cinereoargenteus*), taken at Milford, Conn., he found rabbit hair, parts of a field mouse, sweet corn, pieces of apple, remains of a woodcock, and some leaves.[a]

That shrews destroy many field mice is certain, although the evidence is largely circumstantial. It is known that they eat dead mice that have been caught in traps. It is proved that they are able to capture a live field mouse in its burrow by the fact that when both animals are confined in the same cage the shrew kills and partly eats the other animal. Shrews are often trapped in the burrows of field mice, and it is highly probable that they habitually feed upon the rodents. As they eat only the flesh and blood of their victims it is difficult to identify their food by stomach examinations.

The common brown rat (*Mus norvegicus*) is an enemy of field mice where both occur in the same locality. On the Potomac flats, south of Washington, D. C., both rats and meadow mice (*M. pennsylvanicus*) are abundant. On various occasions, while trapping mice there, specimens in small cage traps were destroyed by rats. Several times I had occasion to uncover burrows and runways of the mice by removing piles of dry weeds. On the following mornings I found that rats had enlarged the burrows in pursuit of mice, and the remains of fur and stains of blood on the ground showed that the pursuit had been successful. It is unfortunate that rats are even worse pests than the field mice they destroy.

Of the other wild mammals that destroy field mice—wolves, coyotes, lynxes, raccoons, and opossums—it may be said that the mouse-eating habit is not always prominent and that their economic status can not be determined by it alone. On the whole, however, their general effect in checking the increase of rodents must be regarded as an important item to their credit.

DOMESTIC MAMMALS.

Some of the domestic animals assist in the destruction of field mice. Cattle and horses in pastures undoubtedly trample upon and destroy many mice, especially the young. Hogs in fields and wood lots root them from burrows and nests and eat them. Aristotle mentions the ancient practice of turning swine among mice "to root up their runs."[b] But the more important of their enemies among domestic animals are dogs and cats.

Dogs follow the farmer to the field and at plowing and harvest are ready to pounce upon and kill every mouse that is uncovered in fur-row or shock. While they seldom eat rats or house mice, they sometimes become very fond of field mice and learn to hunt them independently. A good rat dog is undoubtedly a valuable asset of the farm, and I have known one to keep premises clear of brown rats (*Mus norvegicus*) when adjoining farms were overrun with them.

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[a] Forest and Stream, vol. 55, p. 464, Dec. 15, 1900.

[b] Aristotle's History of Animals, Book 6, chap. 30, p. 178, Bohn's edition, London, 1862.

Many cats are good mousers, both in house and field. Some live largely upon pocket gophers, ground squirrels, and field mice. Unfortunately, however, when cats roam afield they learn to destroy song birds, young poultry, and game. The ordinary farm cat is exceedingly destructive to small birds and game, and the number that cats annually kill is immense.

House cats usually are too well fed to make good mousers, and are believed to aid in the spread of infectious diseases among human beings. In spite of the usefulness of individual cats in destroying mice, every community would be better off for a large reduction in its feline population.

BIRDS THAT DESTROY FIELD MICE.

Many species of birds destroy rodents. Among those that eat field mice are shrikes, cuckoos, crows, herons, bitterns, storks, ibises, gulls, hawks, and owls. Unlike the mammals already named, some of these birds live almost exclusively upon field mice, and hence are of great assistance in reducing their numbers.

BIRDS OF PREY.

At the head of the list of bird enemies of field mice stand the hawks and owls. Most of the species habitually feed upon rodents, a few of them almost entirely. Moreover, the species that feed least upon harmful rodents feed largely upon insects. Thus the beneficial character of hawks and owls as a group is beyond question.

Fortunately the economic status of American hawks and owls does not rest upon mere theory or general assertions without proof. Bulletin No. 3 of the Biological Survey[a] deals with the food habits of hawks and owls of the United States, and is based upon examinations of nearly 2,700 stomachs. Such large series of the more common species were examined that further investigations can but confirm and emphasize the present verdict—that American hawks and owls, as a whole, are among the best friends of the farmer and that only a few species are more harmful than beneficial.[b]

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[a] The Hawks and Owls of the United States in their Relation to Agriculture, by A. K. Fisher, M. D., Washington, 1893.

[b] Doctor Fisher's report on the food of hawks and owls has long been out of print. For this reason some of the more important summaries of results, especially those relating to the mammal food, are given in this paper. Circular 61, Bureau of Biological Survey, Hawks and Owls from the Standpoint of the Farmer, gives a brief summary of the original report by Doctor Fisher, and may be had on application.

HAWKS.—Though hawks are our most common birds of prey, many kinds are too rare to exert a marked effect, either injurious or beneficial, upon the interests of the farmer; but the most common kinds are widely distributed and their voracious appetites make them of considerable economic importance. Nearly all hawks feed more or less upon rodents, and their most frequent victims are the short-tailed field mice.

The marsh hawk, or harrier (*Circus hudsonius*), is probably the most common and most widely distributed North American species. It is of medium size and may easily be recognized, while flying low over fields and meadows, by its conspicuous white upper tail coverts. The results of an examination of 124 stomachs of this species are as follows: Seven contained poultry or game; 34, small birds; 57, mice; 22, other mammals; 7, reptiles; 2, frogs; 14, insects; and 8 were empty. Field mice were positively identified in 44 stomachs, averaging almost two to each stomach. Eight were found in one stomach. The other mammals were mainly ground squirrels (spermophiles) and rabbits.

The buzzard hawks (genus *Buteo*) include seven species and six subspecies, all rather large and slow of wing. They are rarely able to capture a domestic or wild fowl. They live chiefly on small mammals, insects, snakes, and batrachians. The group includes such well-known birds as the red-tailed hawk (*Buteo borealis* and four subspecies), red-shouldered hawk (*Buteo lineatus* and two subspecies), Swainson hawk (*Buteo swainsoni*), and broad-winged hawk (*Buteo platypterus*).

A summary of the food of 562 red-tailed hawks is as follows: Fifty-four of the stomachs contained poultry or game birds; 51, other birds; 278, mice; 131, other mammals; 37, batrachians and reptiles; 47, insects; 8, crayfish; 1, centipedes; 13, offal; and 89 were empty. Two hundred and twenty-eight stomachs contained 350 field mice.

Of 220 stomachs of the red-shouldered hawk 3 contained poultry; 12, other birds; 102, mice; 40, other mammals; 20, reptiles; 39, batrachians; 92, insects; 16, spiders; 7, crayfish; 1, earthworms; 2, offal; 3, fish; and 14 were empty. Sixty-three stomachs contained 89 field mice.

Of Swainson hawks, 18 stomachs were examined. Of these 7 contained small mammals; 8 contained insects; 3, reptiles; 3, batrachians; and 3 were empty. One of the mammals was a mouse, and nearly all the insects were locusts and grasshoppers. Throughout its summer range this species lives almost entirely upon grasshoppers.

Of broad-winged hawks, 65 stomachs were examined, 15 of which contained mice, and 13 other small mammals. No poultry or game birds were found in the stomachs, and the chief food was insects.

The most common Old-World representative of the genus is *Buteo buteo*, the common buzzard of England, and popularly known in Germany as the mouse buzzard (*Mäusebussard*). That the last name is well deserved, is shown from the researches of Dr. G. Rörig, of Berlin, who in 784 stomachs of this species found no less than 1,124 rodents, of which 1,057 were the common field mouse (*M. arvalis*).[a]

Two prominent species of rough-legged hawks (*Archibuteo*) occur in America. Both are winter sojourners with us. The northern form, the common rough-leg (*Archibuteo lagopus sancti-johannis*), summers north of the United States. The ferruginous rough-leg (*A. ferrugineus*), commonly known as the squirrel hawk, nests extensively in the Western States, but is more common there in winter. Both species are large and may be easily distinguished by the feathering of the legs, which extends to the base of the toes. Doctor Fisher examined 50 stomachs, all but 1 being of the common rough-leg. Of these, 40 contained mice only; 5, other mammals; 1, insects and a lizard; and 4 were empty. Of the 40 containing mice, 28 had meadow mice only, the number varying from 1 to 8 and the average being more than 3 to each hawk. These are winter records. In summer the birds doubtless are largely insectivorous. It is certain that the rough-legs do not often molest wild birds or domestic fowls.

The researches of Doctor Rörig make an equally favorable showing for the Old World rough-legged hawk (*Archibuteo lagopus lagopus*). He examined 250 stomachs of that species and found remains of 879 rodents, mostly field mice. Ninety-four per cent of the birds examined by him had eaten injurious rodents.[b]

The true falcons (genus *Falco*) of North America comprise 17 species and subspecies, of which 3 are accidental visitors from abroad, and several others, notably the gyrfalcons, are exceedingly rare within the United States. The various falcons differ much in size, but all are strong and swift of wing. The larger species destroy poultry and game, while the smaller kinds prey upon small birds and insects. All feed to some extent upon mice. The most common species are the duck hawk (*Falco peregrinus anatum*), the prairie falcon (*Falco mexicanus*), the pigeon hawk (*Falco columbarius*), and the sparrow hawk (*Falco sparverius*).

The duck hawk is a rather large falcon, and, as its name implies, preys much upon waterfowl. It destroys also game birds, domestic fowls, pigeons, and small birds. Although it feeds to some extent also upon insects and mice, the habits of the species, on the whole, do not commend it to the protection of farmers and sportsmen.

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[a] Arb. Biol. Abteilung für Land- und Forstwirtschaft, IV Band, 1 Heft, p. 64, 1903.

[b] Arb. Biol. Abteilung für Land- und Forstwirtschaft, IV Band, 1 Heft, p. 74, 1903.

The prairie falcon inhabits the West and Southwest. Its habits are somewhat similar to those of the duck hawk. It feeds largely upon land birds, mammals, and insects. Game birds and tame pigeons are known to be on its "bill of fare."

The pigeon hawk is smaller than either of the two preceding species, and is widely distributed in North and Middle America. It nests chiefly north of the forty-third parallel, except in the higher mountains. It feeds mainly upon small and medium-sized birds, a few field mice, and insects (chiefly dragon flies and grasshoppers). Fortunately for our summer song birds, the pigeon hawk for the most part is migratory within the United States. However, it accomplishes some good by destroying English sparrows.

The sparrow hawk is the commonest of our falcons. While it destroys some small birds, its chief food is insects and mice. It is too small to do much injury to poultry and game, and many of the small birds it captures are the injurious European sparrow. Doctor Fisher's report gives the results of examinations of 320 stomachs of the sparrow hawk. Of these, 1 contained a quail; 53, small birds; 89, mice; 29, spiders; and 29 were empty. The insects were largely grasshoppers, and about half of the mice were field mice.

Two common hawks of the genus *Accipiter* should be mentioned—the Cooper hawk (*Accipiter cooperi*) and the sharp-shinned hawk (*A. velox*). Both destroy many birds and feed only to a small extent upon injurious mammals and insects. The Cooper hawk destroys much poultry and game, while the sharp-shinned hawk lives chiefly upon smaller birds, including quail and young chickens. Although both species prey upon meadow mice, their limited usefulness in this respect does not offset their injurious habits. The thieving traits of these two birds has had much to do with the undeserved ill repute in which hawks as a whole are held.

All the other American hawks and eagles prey to some extent upon field mice. The kites (four species) are highly insectivorous. The Mississippi kite (*Ictinia mississippiensis*), known sometimes as the blue hawk, is locally abundant as a summer resident in southern Kansas, in Oklahoma, and parts of Texas. Its food is almost exclusively grasshoppers, and it seldom molests birds, yet it is often wantonly destroyed by sportsmen simply because it is a hawk and offers a tempting mark. The same may be said of the other kites, including the beautiful and useful swallow-tailed species.

The chief economic function of hawks seems to be the destruction of harmful rodents and insects. A majority of the species are decidedly useful, their good qualities far outweighing the bad. A few have no harmful habits, but are wholly beneficial. A smaller number have good and bad traits nearly balanced, or certain species may be beneficial in some localities but harmful in others. Two common species—the Cooper and sharp-shinned—destroy so many birds and poultry as to far outweigh any good they may do. If legislation against hawks is needed, which is more than doubtful, careful discrimination should be exercised as to the species placed under ban, and corresponding protection should be given those that are of undoubted benefit to the farmer.

OWLS.—Owls are preeminently enemies of mice. Their eyes are adapted to twilight and nocturnal hunting, and they prey mostly upon animals that are active after sunset. Noiseless of wing and possessed of sharp talons and much strength, they attack small mammals with great success.

Owls, and also hawks and some other birds that eat small vertebrates by swallowing them entire, are unable to digest the bones, fur, and feathers. These are thrown up in the form of pellets, the bones being surrounded by fur and feathers. Much of our knowledge of the food of owls is derived from examinations of these pellets.

The American barn owl (*Strix pratincola*) is rather common in the southern half of the United States, breeding as far north as forty-one degrees. In part of its range field mice are common and it preys upon them to a considerable extent. Examinations of 39 stomachs of barn owls were made by Doctor Fisher. Of these, 1 had eaten a domestic pigeon; 3, other birds; 17, mice; 17, other mammals; 4, insects; and 7 stomachs were empty. Meadow mice were found in 9 of the stomachs. The mammals eaten, other than mice, were chiefly ground squirrels (spermophiles) and other injurious species.

Doctor Fisher records the results obtained from an examination of 675 pellets of the barn owl collected at Washington, D. C. They contain remains of 1,731 rodents, 56 insectivorous mammals, 32 birds, and 2 frogs. The rodents were mainly rats (*Mus norvegicus*), house mice (*Mus musculus*), and meadow mice (*Microtus*). Of the last there were 1,123 skulls, or an average of almost 2 to each pellet.[a] Doubtless similar investigations in California, where these owls are common, would show that there spermophiles are the chief food.

The habits of the European barn owl (*Strix aluco*) serve to illustrate further the usefulness of our own bird. Dr. Bernard Altum, a German naturalist, in 1863 recorded the results of examinations of 703 pellets of the barn owl. He found remains of 16 bats, 933 rodents, 1,479 shrews, and 22 small birds (19 of which were sparrows). Of the rodents 693 were voles.[b] Later (1867) he published the results of examinations of 360 additional pellets, making 1,063 in all. The total shows 2,151 insectivorous mammals, and 1,801 rodents, of which 1,284 were voles.[c]

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[a] Science, N. S., vol. 3, pp. 623–624, Apr. 24, 1896.
[b] Journal für Ornithologie, vol. 11, pp. 41–46, 217–219, 1863.
[c] Zoologische Garten, vol. 8, pp. 263–264, 1867.

The Reverend Doctor Jäckel, of Windsheim, Bavaria, collected and examined a total of 6,512 pellets of the barn owl. In them he identified skulls of 5,210 shrews and 14,790 rodents, of which 9,046 were *Microtus*.[a] Doctor Rörig more recently examined 121 pellets of barn owl and in them identified 291 voles, 68 true mice, 35 shrews, and 13 sparrows,[b] a result more in harmony with Doctor Fisher's tables.

John Watson calculates that each pair of owls of this species while feeding their young capture at least 40 mice per day. Once he found no fewer than 17 recently killed field mice on the side of a barn owl's nest which contained 5 young owls.[c] The late Edward Newman stated that every owl of this species is worth £5 per year to the British nation.[d]

The long-eared owl (*Asio wilsonianus*) is distributed throughout temperate North America, except the treeless plains. It is a constant resident over most of its range, and its usefulness in the destruction of mice continues throughout the year. Of the 107 stomachs examined by Doctor Fisher, 1 contained a quail; 15, other birds; 84, mice; 5, other mammals; 1, insects; and 15 were empty. Of the 84 containing mice, 46 contained specimens positively identified as meadow and pine mice. About 50 pellets cast up by long-eared owls contained 176 skulls, representing 93 meadow mice, 19 pine mice, 23 other mice, 26 shrews, and 13 small birds.

The long-eared owl (*Asio otus*) of the Old World has a similar record. Doctor Rörig made 108 stomach examinations of this species. In the stomachs he identified 20 small birds, 1 weasel, 2 bats, 18 shrews, 29 true mice, 14 bank voles (*Evotomys*), and 365 field mice (*Microtus*). Nine stomachs contained insects. Eighty-four per cent of the birds had eaten mice. A single stomach contained 12 field mice.

In 142 pellets of *A. otus* examined by Doctor Altum, he found 3 small birds, 2 shrews, 14 true mice, 12 bank voles, and 259 voles (1 *M. amphibius*, 65 *M. agrestis*, and 193 *M. arvalis*.[e] Doctor Rörig examined 1,053 pellets of long-eared owl and found remains of 14 small birds, 1 frog, 2 moles, 29 shrews, 22 true mice, 15 bank voles, and 1,764 voles. Selby found 5 mice in a single stomach of this species.

The short-eared owl (*Asio accipitrinus*) is probably the greatest enemy of field mice. It figures in many historical accounts of vole plagues in England and on the Continent. Holinshed's Chronicle closes the account of voles in Danesey Hundred, of the county of

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[a] Zoologische Garten, vol. 15, p. 469, 1874.

[b] Arb. Biol. Abteilung für Land- und Forstwirtschaft, IV Band, 1 Heft, pp. 102–104, 1903.

[c] Ornithology in Relation to Agriculture and Horticulture, p. 12, London, 1893.

[d] Hardwicke's Science Gossip, vol. 29, pp. 89–90, 1893.

[e] Journal für Ornithologie, vol. 12, pp. 429–434, 1864.

Essex, in 1581, by saying: "Which vermin by policie of man could not be destroyed, till at the last there flocked together such a number of owles as all the shire was not able to yield, whereby the marsh holders were shortly delivered from the vexation of the said mice." Similar testimony as to the efficiency of owls as destroyers of voles is contained in other chronicles, and in the account of later outbreaks the species is definitely stated to be the short-eared owl.

The short-eared owl inhabits the temperate parts of both continents. In each its range extends northward well beyond the Arctic Circle. It is an irregular migrant and always appears in large numbers where voles, lemmings, or other mice become unusually abundant. It nests on the ground in tall grass, usually in moist meadows, a habitat peculiarly fitted for the operations of this consumer of meadow mice. Doctor Fisher reports the results of examinations of 101 stomachs of this species. Of these, 11 contained small birds; 77, mice; 7, insects; and 14 were empty. In the 77 stomachs that contained mice fully a hundred field mice were identified. Doctor Rörig examined 51 stomachs of this species and found in them remains of 90 injurious rodents, of which 76 were *Microtus*. He examined also 480 pellets of this owl, finding remains of 3 beetles, 9 small birds, 7 bank voles, 22 *Microtus agrestis*, and 842 *M. arvalis*.

For purposes of comparison, the results of the examinations of owl pellets are here presented in tabular form. The figures, disregarding fractions, represent the average number of individual mammals and birds found in 100 pellets of each species of owl.

Kind of mammal or bird found in owl pellets.	Barn owl.				Long-eared owl.			
	Strix pratincola (Dr. Fisher).	*Strix aluco* (Dr. Altum).	*Strix aluco* (Rev. Jäckel).	*Strix aluco* (Dr. Rörig).	*Asio wilsonianus* (Dr. Fisher).	*Asio otus* (Dr. Altum).	*Asio otus* (Dr. Rörig).	Short-eared owl—*Asio accipitrinus* (Dr. Rörig).
Harmful rodents:								
Mus (rats and mice)	87	18	87	56	46	10	2	0
Microtus (field mice)	166	121	139	241	114	182	168	180
Other rodents	3	[a] 4	[a] 1	0	0	[a] 8	[a] 2	[a] 1
Insectivorous mammals (shrews, moles, and bats)	8	202	80	29	52	1	3	0
Small birds (sparrows, etc.)	5	3	([b])	11	26	2	1	2

[a] Bank voles (*Evotomys*).

[b] Not given.

The barred owl (*Syrnium varium*) is larger than the species already considered. It resides throughout eastern North America from Nova Scotia to the Gulf and westward to the treeless plains. It usually lives in rather dense forests and swamps and nests in hollow trees. Owing to its greater size, its food includes larger mammals and birds than that of the last three species. Thus, it is able to carry off a good-sized domestic fowl, and no doubt occasionally it raids poultry. However, Doctor Fisher's examination of 109 stomachs of this species indicates that it is far less harmful than is generally supposed. Five stomachs contained poultry or game; 13, other birds; 46, mice; 18, other mammals; 4, frogs; 1, lizard; 2, fish; 14, insects; 9, crayfish; and 20 were empty. Field mice were positively identified in more than half of the 46 stomachs that contained mice.

The great horned owl (*Bubo virginianus*) is the largest owl resident in the United States. Its range, including the subspecies, extends from Costa Rica to the northern limit of deep forests and from ocean to ocean. In South America occur a number of closely related forms.

The great horned owl has an evil reputation with most farmers on account of its destruction of poultry. The bad reputation is only partly merited. Doctor Fisher examined 127 stomachs of this species. Of these, 31 contained poultry or game birds; 8, other birds; 13, mice; 65, other mammals; 1, a scorpion; 1, a fish; 10, insects; and 17 were empty. About half the mice found were meadow voles and the majority of the "other mammals" were rabbits. In central Kansas, some years ago, I examined over a dozen nests of this species in which young were being fed. The nests contained rabbits (*Lepus floridana mearnsi*), fox squirrels (*Sciurus rufiventer*), wood rats (*Neotoma baileyi*), skunks (*Mephitis*), field mice, and in two cases feathers of the flicker (*Colaptes auratus luteus*), but in no case any feathers or remains of poultry. In the few cases in which these owls were observed by me to raid poultry the fowls were roosting upon trees late in the fall, and hence were unnecessarily exposed to attack. Where rats are abundant this owl has been known to prey largely upon that rodent. O. E. Niles, in a letter to Charles Dury, dated March 5, 1885, stated that at one time the remains of no less than 113 rats had been counted under the nest of a great horned owl.[a] On the whole, the great horned owl is not a very harmful species, and as it is rapidly disappearing in most parts of the United States warfare against it may be suspended.

The screech owl (*Otus asio*) is probably the most familiar of American owls. Including its ten or more geographic races, it has a wide distribution. It is too small to prey upon domestic fowls or game and is beneficial. Doctor Fisher reported on the contents of 255 stomachs, of which 1 contained a tame pigeon; 38, other birds; 91, mice; 11, other mammals; 6, lizards and batrachians; 1, fish;

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[a] Jour. Cin. Soc. Nat. Hist., vol. 8, p. 63, 1885–86.

100, insects; 5, spiders; 9, crayfish; 11, miscellaneous; and 43 were empty. A good proportion of the "other birds" were English sparrows. About a third of the mice were identified as meadow mice, while 24 were house mice. The large proportion of insects eaten is remarkable.

The burrowing owl (*Speotyto cunicularia hypogæa*) is a small species, common on western plains, and noted for its abundance during summer in prairie-dog "towns," where it occupies the deserted burrows of that rodent. Of 32 stomachs of this owl examined by Doctor Fisher, 2 contained mice; 1, a prairie dog; 3, lizards; 3, scorpions; 1, a centiped; 30, insects, and 1 was empty. The species is largely insectivorous and undoubtedly highly beneficial.

Several other species of owls occur in the United States, but at no season are they abundant over any considerable area. Probably all feed largely upon meadow mice. Doctor Fisher's report covered only a small series; but 6 out of 9 great gray owl stomachs, 4 out of 22 sawwhet owl stomachs, 10 out of 38 snowy owl stomachs, and the single hawk owl stomach examined contained the remains of field mice.

From the testimony of Doctors Fisher, Altum, Jäckel, and Rörig, and careful observations by others, the great value of owls for reducing the number of meadow mice is established beyond doubt, and the various species should everywhere be protected by legal enactments.

CROWS.

Among the most formidable bird enemies of field mice are the larger members of the crow family (*Corvidæ*). The fact that ravens, hooded crows, and rooks in the Old World feed upon voles and lemmings has often been noted. American crows have similar habits and feed upon field mice whenever occasion offers. Besides the common crow (*Corvus brachyrhynchos*) the list of mouse-eating crows includes the fish crow (*Corvus ossifragus*), the northwest crow (*Corvus b. caurinus*), the raven (*Corvus corax sinuatus*), and the white-necked raven (*Corvus cryptoleucus*). Magpies and the larger jays also destroy mice to some extent.

The food habits of the common crow form the subject of Bulletin No. 6 of the Biological Survey.[a] The results of examinations of 909 stomachs of crows are tabulated in the report. Of this number, 78 contained mice, they being fourth in order of importance on the list of animal food for the year. Professor Barrows says: "There is abundant proof from several sources that crows often capture living mice, particularly the short-tailed field mice, which build their nests usually on the surface of the ground among the roots of grass. Here the crows discover them, and, tearing the nest to pieces, devour the young and not infrequently catch the adults as well. By far the greater number of the mice found in the stomachs were meadow mice, or voles (genus *Microtus*), and most of them were the common species (*Microtus pennsylvanicus*)."

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[a] The Common Crow of the United States, Walter B. Barrows and E. A. Schwartz, 1895.

In midwinter, when the ground is covered with snow, crows find but few field mice; but as spring approaches and the snow begins to melt on the meadows, the bulky grass nests of the mice are first exposed. The crows may then be seen searching the meadows for them. They alight near the openings in the snow, pounce upon the nests, tear them to pieces, and as the mice scamper out the crows often succeed in capturing them. Later in the spring, when crows feed their nestlings, insects are more abundant and the nests of mice are hidden in the growing grass, so that relatively fewer mice are eaten. Still later, after the young crows have left their nests and mowing machines have once more exposed mouse nests in the meadows, crows again spend much time searching for young meadow mice.

It is of interest to note that complaints of recent depredations of field mice are especially numerous from sections of the United States where for several years past bounties have been paid for killing crows.

CUCKOOS AND SHRIKES.

The larger species of the family of cuckoos (*Cuculidæ*) are known to feed extensively upon vertebrates. The two more common cuckoos of the United States are too small to share this habit, but the roadrunner (*Geococcyx californianus*) of the Southwest feeds rather commonly on reptiles, batrachians, and small rodents. Prof. F. E. L. Beal captured one in California which had eaten a field mouse (*M. californicus*).

The great northern shrike (*Lanius borealis*) is a common winter visitor in the northern half of the United States. It arrives from the north in October and remains until March or April. It is a familiar bird to most residents of rural districts. Gray in general color, with black wings, conspicuously barred with white, and with white in the tail, it looks much like a mocking bird, but has a strong, sharply-hooked bill, which enables it to kill small birds and mice. In its summer home it is probably much more insectivorous than with us. It comes to the United States at a time when insects are not abundant, and feeds mainly upon small birds, mammals, and grasshoppers. Mice were found in one-third of the stomachs examined by the Biological Survey and more than half of those identified were meadow mice. Doctor Mearns is quoted[a] as authority for the statement that in Minnesota during March shrikes live almost exclusively on meadow mice. Most farmers have noticed that the northern shrike, or "butcher bird," catches meadow mice. The birds are often seen at husking time as they hover in the air or sit on a fence post or top of a hedge, ready to pounce upon every mouse that escapes from corn shocks as they are torn down or moved.

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[a] Bulletin 9 of the Biological Survey, Cuckoos and Shrikes in their Relation to Agriculture, p. 19, 1898.

The smaller shrikes (*Lanius ludovicianus* and subspecies) also somewhat resemble mocking birds in color. They are summer residents of many parts of the United States. As insects are abundant during the greater part of their stay, they are insectivorous to a greater extent than the northern shrike. Stomach examinations prove that mice form 16 per cent of the food for the entire year, but the birds are less able than the larger species to cope successfully with adult meadow mice, yet they undoubtedly destroy a good many voles, and several have been identified in their food; but smaller mice are more frequently caught.

Although shrikes destroy a few useful birds, they more than compensate for this by their destruction of small rodents and insects, and they fully merit protection by the farmer.

OTHER BIRDS.

Members of the order *Herodiones*, including herons, storks, and ibises, are usually persistent enemies of meadow mice. Many of them frequent meadows and swamps, especially in the breeding season. Unfortunately, the summer range of the larger number of species is too far south to bring them much in contact with voles. However, a few species spend the summer where mice abound and make them an important part of their food.

Of our herons, the American bittern (*Botaurus lentiginosus*) is probably the best known destroyer of voles. The bird is a summer resident in all suitable localities in temperate North America, making its home in moist meadows, bogs, and swamps. Baird, Brewer, and Ridgway say of it: "It does not move about much by day, although it is not strictly nocturnal, but is sometimes seen flying low over the marshes in pursuit of short-tailed or meadow mice, which are frequently taken whole from its stomach."[a] Records of the Biological Survey contain a number of instances in which meadow mice were found in stomachs of this species.

Among other *Herodiones* that feed upon meadow mice are the least bittern (*Ardetta exilis*), wood ibis (*Tantalus loculator*), great blue heron (*Ardea herodias*), American egret (*Herodias egretta*), snowy heron (*Egretta candidissima*), and the black-crowned night heron (*Nycticorax nycticorax nævius*). While frogs, fish, and fresh-water crustaceans form the major portion of their food, they feed also upon mice, shrews, and other small mammals. As a group they undoubtedly effect a reduction in the numbers of meadow mice in America.

During a plague of field mice (*Peromyscus* in this case) in South America in 1872–73 Mr. W. H. Hudson observed that storks became very numerous. He says: "In the autumn of the year [May, 1873] countless number of storks (*Ciconia maguira* [*Euxenura maguira*]) and short-eared owls (*Asio accipitrinus*) made their appearance. They had also come to assist in the general feast. * * * Years have perhaps passed during which scarcely an individual of these kinds has been seen; all at once armies of majestic white storks are seen conspicuously marching about the plain in all directions, while the night air resounds with the solemn hootings of innumerable owls."[a] European writers bear testimony to the usefulness of the common stork (*Ciconia ciconia*) in destroying voles and other kinds of mice.

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[a] The Water Birds of North America, vol. 1, p. 70, 1884.

The family of cranes (*Gruidæ*) range farther north than the herons, and the three North American species are known to feed to some extent upon voles, capturing both young in the nests and adults. The habitat of cranes includes upland prairies as well as moist meadows, and thus probably they prey upon more species of voles than herons do.

Although the usual food of gulls (*Laridæ*) consists of fishes and insects, they feed also upon rodents. During the vole outbreak in Scotland in 1892 several species of gulls, notably the great black-backed gull (*Larus marinus*), fed upon the field mice; and gulls are usually named among the species that feed upon lemmings during their migrations. It is highly probable that the larger American gulls feed upon field mice whenever they find them.

SNAKES.

Snakes must be included among the natural enemies of field mice. While nearly all snakes feed extensively upon insects, many of them eat vertebrates, including fishes, reptiles, batrachians, birds, and mammals. The larger bull snakes (*Pituophis*), black snakes (*Callopeltis*), and rattlesnakes (*Crotalus*) of the United States feed largely upon mammals, including rabbits, prairie dogs, pocket gophers, and ground squirrels, as well as different species of rats and mice. Black snakes and bull snakes probably kill more field mice than the others; but black snakes destroy also a considerable number of nestling birds and birds' eggs, so that part of their beneficial work is offset by this injurious habit. A nurseryman in Pennsylvania reports that he secured immunity from mice in his nursery by turning loose in it 50 black snakes. On the whole, snakes, except the venomous species, are deserving of the farmers' protection. Like the toad, the smaller kinds feed almost wholly upon insects; but an inherent prejudice induces thoughtless people at every opportunity to destroy these friends of agriculture.

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[a] Naturalist in La Plata, pp. 64–65, 1892.

REPRESSION OF FIELD MICE—ACTIVE MEASURES.

We pass now to a consideration of such means for the repression of voles as are under the immediate control of the farmer. These consist of trapping and other mechanical methods of destruction and the use of poisons, fumes, and micro-organisms.

TRAPPING.

Trapping is a simple way to destroy field mice, but it is seldom resorted to because few people have patience to follow it up persistently and to look after the necessary large number of traps. When field mice are abundant it is essential to use many traps and to continue trapping for several weeks. Equipped with a hundred or more effective traps, a good trapper should be able to make decided inroads upon the numbers of the pests, if not to practically exterminate them over a limited area.

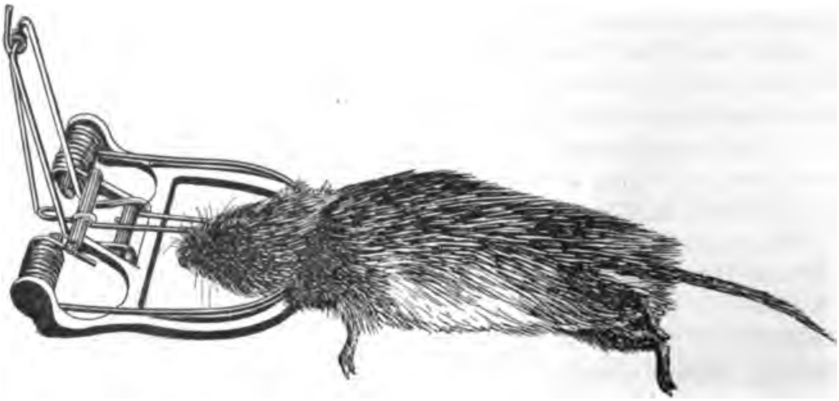

FIG. 2.—Field mouse caught in baited guillotine trap.

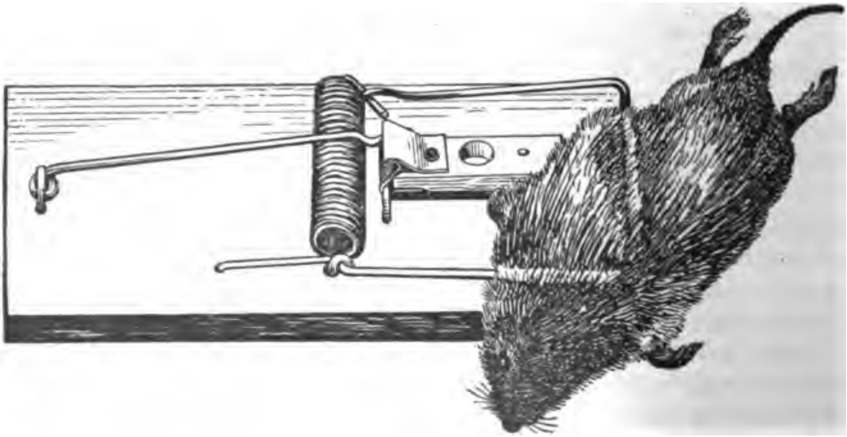

FIG. 3.— Field mouse caught in unbaited guillotine trap.

Trapping has special advantages for small areas such as lawns, gardens, and vegetable or nursery pits and packing houses, where a limited number of mice are present, and wherever, for any reason, there are objections to the laying out of poison. As voles do not readily enter cage traps, simple wire traps of the guillotine order, in which mice are instantly killed, are the most effective (text figures 2 and 3).

Traps without bait may be set across the runs of the mice, where the animals spring them by coming in contact with the trigger, or they may be baited with oat or corn meal. For trapping pine mice an opening should be made in the underground tunnel large enough to receive the trap, which should be set across the bottom of the runway. The traps may be baited or not, but the opening should be covered.

CULTIVATION.

Thorough cultivation of fields tends to keep down the number of voles. Cultivation implies the destruction of weeds and all the annual growths that provide winter shelter for the animals. The mere plowing of a field badly infested by mice is sufficient to drive out most of them. However, as a rule the animals escape to adjoining fields and return to their old haunts when growing crops or weeds afford sufficient shelter.

The Scottish vole plague of 1892–93 originated in hill pastures, where heather, moss, and numerous grasses afforded abundant shelter. The outbreak on the border farms in 1876–77 occurred under similar conditions. The Thessalian vole plague of 1891 and 1892 apparently grew out of peculiar conditions of cultivation. The district visited by the mice is an extremely fertile one on the plains near Larissa. The lands are mostly in large holdings, the owners of which rent the fields to peasants who live in the villages. Owing to primitive methods of cultivation, each peasant has only a small tract. As the number of renters is small, a system of rotation is practiced which brings the same tracts into cultivation about once in three years, while two-thirds of the district lies fallow. In the fallow lands voles multiply until at times they invade the cultivated lands and ruin the crops.[a]

While a high state of tillage does not always bring immunity from voles, it does much to lessen the danger of attacks from them. A system which regularly brings all the land of a district under the plow and permits little of it to lie unused will secure the greatest immunity from these pests.

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[a] Prof. T. Loeffler, Centralblatt für Bakteriologie und Parasitenkunde, vol. 12, pp. 1–17, July 5, 1892.

OTHER MECHANICAL DEVICES.

Mechanical methods of destroying voles have long been in use, and sometimes are effective. In some countries where the animals are abundant, considerable reliance is placed upon the efforts of laborers armed with spades and other digging tools and assisted by dogs. In this manner thousands are sometimes killed.

Trenching also is a favorite method of catching both mice and moles. Trenches a foot and a half deep are dug at intervals about the infested lands. They are wider at the bottom than at the top, or have perpendicular sides. The animals fall into these pits and are unable to climb out. Men and dogs regularly make the rounds and despatch the animals thus caught. This method was used effectively in Dean and New Forests in 1813 and 1814 and in the later vole plagues of Great Britain and central Europe.

Inundation with water and fumigation with sulphur have been employed to some extent in killing field mice. All these mechanical methods involve much labor and are slow and often expensive.

POISONING.

As the laying out of poison for wild animals is attended by danger to other animals and to human beings, it should never be intrusted to the ignorant or careless. In some countries the laying of poison is forbidden by law, and several of our own States have enactments regulating the practice or forbidding it. The majority of States have no legislation prohibiting the use of poison, and the matter is usually left to the judgment of the individual farmer, to whom attaches responsibility for any damage that may result through his carelessness.

STRYCHNINE.

All things considered, strychnine is the most satisfactory poison for field mice. Although a very deadly substance, it is less dangerous to handle than either phosphorus or potassium cyanide. Its extreme bitterness renders it less liable to be mistaken for a harmless drug. Nevertheless, every precaution should be taken in handling it. The strychnine salt most used commercially is strychnia sulphate. This is the best for poisoning purposes, since it is soluble in boiling water, while the alkaloid requires the presence of an acid for its solution. To disguise the bitterness of the poison when employed for rodents, sugar is used, or the strychnine may be mixed with its own bulk of commercial saccharine.

For poisoning field mice various baits may be recommended, such as wheat, oatmeal, and corn, among the grains, and seeds of various plants, as the tomato, dandelion, sunflower, and others. The bait should be soaked over night in a poisoned sirup, which may be prepared as follows:

Dissolve an ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. The prepared sirup may be scented by a few drops of oil of anise or rhodium, but this is not essential. A half ounce of borax is said to keep the mixture from molding.

The above quantity (a quart) of sirup is enough to poison a half bushel of wheat or corn, but smaller proportional quantities of grain and sirup may be mixed as needed. If after thorough mixing the solution is not sufficient to wet all the grain, add a little water. After standing over night, if the grain is too wet, a little dry corn meal will take up the excess of moisture. If oatmeal is used as a bait, when the mass is wet throughout with the sirup, it may be used immediately.

Because of the danger of destroying native birds, such as quail, sparrows, and others, the poisoned bait should not be placed in exposed situations, but under shelters which will admit mice but exclude birds. Wide boards lying upon thin cross pieces of wood are excellent for the purpose. For pine mice baits may be placed in the underground tunnels without endangering birds. For other mice pieces of drain tile about 1½ inches in diameter may be laid along the trails, and the baits inserted into the tiles with a long knife or spoon. Tiles are recommended by the French Minister of Agriculture, but old tin cans with flattened ends or small openings are excellent substitutes.

In winter the following plan is especially recommended for orchards and nurseries:

Cut small twigs from branches of apple trees (suckers are excellent for the purpose) and either dip them in the strychnine sirup or apply the sirup to them with a brush. Scatter the poisoned twigs near the trees to be protected. This plan is excellent for either field mice or rabbits, and it entirely obviates the danger of poisoning birds or domestic animals.

OTHER POISONS.

Among other poisons that have been recommended for the destruction of field mice are phosphorus, potassium cyanide, and various mineral poisons, including arsenic. The mineral poisons as a rule are less virulent than the others.

Phosphorus, when properly used, is an excellent though rather slow poison for rodents, a very small quantity producing death. It is, however, dangerous to handle both because of the liability of severe burns and because of the danger of serious conflagrations. Its use in the West to destroy ground squirrels frequently results in the burning of standing grain and in extensive prairie fires. For these reasons we do not recommend its use for poisoning mice.

Potassium cyanide is a most deadly poison, almost tasteless, and with no known antidote. It is therefore dangerous to man, and its general use for poisoning rodents can not be recommended. It is open to the further objection that upon exposure to air it rapidly decomposes and becomes less effective.

Among the mineral poisons that have been successfully employed in destroying field mice is barium carbonate. This substance is comparatively cheap, and is both odorless and tasteless, so that rodents do not detect its presence in food. Its action in the digestive tract of rats and mice is slow, but reasonably sure to produce death. Larger animals are not affected by small doses of the poison, such as would be put out to kill mice; and for this reason its use is attended with less danger than that of strychnine or arsenic.

This poison is usually administered in the form of dough made of four-fifths flour or meal and one-fifth barium carbonate. A little sugar is added to sweeten the mixture, and, if desired, a couple of drops of anise oil. The dough is cut into small lumps (the size of a large pea) for mice, but larger ones are required for rats. The poison may be fed also in moistened bread or oatmeal.

Although the advantages of barium carbonate as a rodent poison have been long known, it has recently been brought into prominence on account of successful experiments in destroying field mice with it made by Dr. Lorenz Hiltner, of Munich, Germany,[a] and by E. Schribaux in France.[b]

Winter is the most favorable season for poisoning field mice. Summer poisoning is usually less successful, on account of the abundance of green food. Although the animals are active in nearly all kinds of weather, they move about more freely in winter when it is comparatively warm. For the best results, therefore, poison should be set out in the evening of rather mild days. Since mice usually work under the snow, it is useless to put out poison for them on the surface of the snow.

The importance of protecting birds during poisoning operations can not be too earnestly insisted upon. In France, in 1905, a great scarcity of birds, particularly partridges, was noticed in the departments of Vienne, Deux-Sevres, and Charente, which was attributed to the extensive use of poisons during 1904 to destroy field mice.[c]

Says the editor of Western Field, of San Francisco, Cal.: "In two or three counties in this State—notably in that of Santa Barbara—the quail, dove, and song birds are being threatened with actual extermination from poison put out by farmers with the intent of killing off the ground squirrel pests. The poison has been scattered indiscriminately over wide areas, and reliable observers keep sending in reports of their finding thousands of dead birds of all kinds, victims of the squirrel bane."[d]

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[a] Praktische Blätter für Pflanzenbau und Planzenschutz, vol. 1 (new series), pp. 112–116, November, 1903.

[b] Journal d'Agriculture Pratique, vol. 9 (new series), No. 22, pp. 708–710, 1905.

[c] Journal d'Agriculture Pratique, Sept. 14, 1905, p. 327 (quoting the journal Temps).

[d] Western Field, vol. 8, No. 1, p. 57, February, 1906.

ADDITIONAL METHODS OF POISONING.

The following recipes and recommendations contain useful hints to farmers who for any reason do not wish to follow the recommendations already made:

To protect trees from mice we take blocks of wood 6 inches in length by 3 in diameter, and with a six-quarter auger bore a hole 4 inches in depth. Mix a dessert spoonful of arsenic with a quart of corn meal, or in that proportion, put one spoonful in each box prepared as above, and put it under each tree beneath the mulch. Renew the meal once or twice each year. This process is a sure protection.—Lewis H. Spear, in U. S. Agricultural Report for 1852, p. 153.

Different poisonous preparations have been used with effect on these vermin. The following are among the best:

Two ounces of carbonate of barytes, mixed with a pound of suet or tallow; place portions of this within their burrows or about their haunts. It is greedily eaten, produces great thirst, and death ensues after drinking. This is an effective poison, as it is both tasteless and odorless. Or,

Two ounces finely powdered arsenic, 2 ounces lard, 10 drops oil of rhodium, mixed with flour or meal into a thick dough, and pills of it scattered about the orchard and nurseries.—E. A. Samuels, in U. S. Agricultural Report, 1863, p. 272.

These animals (*M. agrestis*) had devoured the succulent flower stems of some hundred *Lobelia cardinalis* and the fleshy stems of Pampas grass (*Arundo conspicua*). After making a number of futile experiments, I noticed the animals feeding on dandelion seeds. Securing some ripe heads of dandelions and cutting off the down, I steeped them in a solution of strychnine and laid them in the runs of the voles. In a few days I had exterminated all of them from the garden.—D. Melville, in Annals of Scottish Natural History, January, 1893, pp. 41–42.

In the month of February half a ton of one-and-a-half inch drain tiles were laid down separately throughout the plantations and a teaspoonful of oatmeal was placed in each, which was soon discovered and eaten by the mice. Phosphorus paste was then added to the meal and latterly small quantities of arsenic. The plan succeeded perfectly, and in a very short time they were all destroyed.—Sir Robert Menzies, Rannock, Perthshire, Scotland.

A mixture of four-fifths flour and one-fifth arsenic is introduced by the aid of a small palette knife into the middle of a drain pipe with an internal diameter of about 3 centimeters (1¼ inches), and this pipe is then put near the holes of the mice.—Recommended by the French Minister of Agriculture in a letter to the British Vole Commission of 1892.

I shell out pumpkin seed, grind it into meal, and mix with strychnine. This is put into a tomato or corn can, the sides bent flat, so that no other animal can get at the meal, and the can then laid on the side. It is a great success.—Method used by Fred. Noerenberg, Cascade Springs, S. Dak.

FUMIGATION.

Generally speaking, the various methods of fumigation for destroying field mice are unsuccessful. Nearly all the species have numerous burrows, and it is difficult to determine the occupied ones. To insure success, therefore, all the burrows must be fumigated, and the amount of labor and material involved makes the methods too expensive. However, occasionally carbon bisulphid may be used to advantage, especially with pine mice. A little of the liquid is poured upon a piece of rag or other absorbent material and this pushed into the burrow, which at once should be closed with soil to confine the gas.

MICRO-ORGANISMS.

The efforts of Löeffler, Danysz, Mereshkowski, and other European bacteriologists to destroy field mice by means of infectious diseases have been partially successful, but as yet no disease appears to have been found that is really contagious. As long, therefore, as infection can be effected only by direct inoculation or through the food, the methods have little, if any, advantages over ordinary poisons.

The Biological Survey, cooperating with the Bureau of Animal Industry, is engaged in experiments with various micro-organisms for destroying field mice and other rodents, and practical results along these lines may yet be reached.

RECOMMENDATIONS TO FARMERS.

When conditions are unusually favorable for an increase of voles, the farmer should put forth all possible efforts to repress them. With cooperation among the farmers of a district serious losses may readily be prevented. The danger lurks outside of cultivated areas and in the swamps, forests, and waste places along fence rows and small brooks that harbor weeds and underbrush. It is by giving attention to these and by reducing to a minimum the extent of shelter for mice that the farmer can most successfully protect his crops.

A second important consideration is the protection of animals and birds that prey upon field mice. The farmer should by all means acquaint himself with the food habits of the various species of wild animals of his vicinity, to the end that he may distinguish friend from foe. Every farmer can do much in his community to help form an enlightened sentiment in favor of beneficial birds, mammals, and other animals.

PREVENTION OF INJURY TO ORCHARDS AND NURSERIES.

Injury to orchards and nurseries by field mice may generally be prevented by forethought and the exercise of ordinary care. Of first importance, always, is clean tillage. No grass or weeds should be left in or near the nursery. So well is this understood by the majority of experienced nurserymen that by clean tillage they secure practical immunity from the ravages of mice except in winters of deep and long-lying snow. If grass and weeds are destroyed in fence corners and waste lands near the nursery, complete immunity from mice ravages can be depended upon even in winters of deep snow.

Unfortunately, nurserymen can not control the lands which environ their trees, and when snow falls to a considerable depth prompt measures are sometimes necessary to keep mice from destroying them.

This can be accomplished most readily by dragging a heavy log or stick of timber several times around each block of trees, packing the snow so firmly that mice can not tunnel under it. If this precaution is taken promptly after the first snow fall, subsequent falls will require but little attention. Some nurserymen plow furrows on both sides of the trees, throwing up the soil in a ridge along the rows; but the expedient is of doubtful utility.

Much of what has been said about the nursery will apply as well to young orchards. Clean cultivation is equally important, and under no circumstances should matted grass be allowed around the trunks of trees or litter be permitted to accumulate in the orchard or along its borders. In case of heavy snows, dragging should be resorted to or the snow stamped down carefully around each tree.

In the absence of snow, a cleared space of about 18 inches radius about the trunk of each tree is enough to prevent damage. The surface of the cleared space should be as smooth as possible, as even clods of earth may afford shelter for mice.

If any part of the orchard is so located as to be subject to snowdrifts and mice are abundant in the vicinity, tree protectors should be used. These may be had of dealers for 60 to 75 cents per hundred or they may be made by the farmer. Those offered for sale are usually wood veneers of some sort. In California the wood of a yucca (*Yucca brevifolia*) is utilized for the purpose. Strips of wire cloth make excellent protectors, and tarred paper is a favorite with some horticulturists. The wire cloth or paper is cut into strips about 7 inches wide and at least 15 inches long. A strip is secured around each tree with wire or cord. Tarred paper should never be used on very young trees, and when used on others should not be left in place during the summer, since it may injure the growing tree.

Various paints and washes have been recommended to prevent attacks of mice and rabbits in orchards. The majority of these are without merit and some of them are liable to kill young trees. Some of the washes require renewal after every hard rain. In experiments with a wash of whale-oil soap, crude carbolic acid, and water, for apple trees, it was found that in about forty-eight hours the carbolic acid had so far evaporated that mice renewed their work upon the bark. Blood and grease, said to give immunity from rabbit attacks, would invite the attacks of field mice.

Reports recently received by the Biological Survey seem to indicate that the ordinary lime-and-sulphur wash, recommended for the winter spraying of trees to destroy the San Jose scale, is an effective preventive of the attacks of both mice and rabbits. Personal observations during the winter of 1906–7 indicate that this claim is well founded. Several correspondents state that they have tried the wash successfully, and the matter is worth further investigation. The wash is very cheap (from 1 to 2 cents a gallon when prepared in 45 to 50 gallon quantities) and is easily applied to the trunks of trees either in the form of a spray or by the use of a brush. One thorough application in November would probably be effective for the entire winter. The ingredients of the wash are 20 pounds of unslaked lime, 15 pounds flowers of sulphur, and water to make 45 to 50 gallons. The mixture should be boiled in an iron kettle at least an hour and applied to the trees while warm.[a]

Winter mulching of trees is dangerous, unless the neighborhood is known to be free from mice. Mulch containing straw may be placed in the orchard in spring, but it should be removed before the approach of cold weather. Fine, thoroughly rotted manure may be used in the orchard with but little danger. Lime or ashes about the trunks of trees has some value in keeping off mice, but clean cultivation is equally or more effective.

REMEDIES FOR INJURED TREES.

When trees are girdled by mice, portions of the inner bark (cambium layer) are often left, partly covering the hard wood below. If sunlight and wind have free access to the injury, the remaining bark dries up and the tree dies. If light and air are excluded, new bark will form and the wound quickly heal over. To facilitate the healing process, it is important that wounds be covered as soon as possible. As a covering for wounded trees, wax, paint, strips of cloth, clay, and cow dung have been recommended, but none of them has any advantages over fresh, loose soil. Unless the ground is frozen, this is always available and easily applied to wounds near the ground. All that is needed is to mound up the soil about the trunk of the tree high enough to cover the wound. Allowance should be made for settling of the soil, and the covering should remain during the entire summer. Plate VIII shows trees 5 inches in diameter which were completely girdled by mice in December, 1903. Soil was heaped about the trunks in January, 1904, and allowed to remain until May, 1905, when it was removed and the photographs made. New bark completely covered the wounds, leaving slight visible scars.

If large fruit trees are injured high up, as sometimes happens when snow is drifted about them and mounding up the soil is impracticable, there are other means of saving them. If the injury is not too extensive, grafting wax should be applied to the wounds and the tree wrapped with strips of cloth. If, however, the cambium be eaten through over considerable surface, bridge grafting may be resorted to.

Bridge grafting is not difficult. It consists in bridging over the girdle of eaten bark by means of scions or small twigs of the same kind of tree. The injured bark at the top and bottom of the wound should be cut back to live, healthy tissue and small clefts or notches made in it. The ends of the scions are then cut to fit these notches, the scion itself being left slightly longer than the span of the injury, so that they may be sprung into position and held firmly. The cambium layer of tree and scion should meet over as much surface as possible. Some operators use a chisel to cut the notches and a small nail or tack at each end to hold the scion in position. The last step is to cover all exposed cut surfaces with grafting wax or to bind all with waxed cloth so as to exclude air until the scions are firmly united with the tree.

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[a] See Yearbook U. S. Dept. of Agriculture, 1906, pp. 429–446, Lime-sulphur Washes for the San Jose Scale.

If young orchard trees are but slightly injured a covering of grafting wax may be applied with good results, though a covering of soil is equally effective. The usefulness of paints for damaged trees depends both upon the stage of growth and the composition of the paints. Some are said to kill trees if applied in the spring. Coal tar will do the same, as the writer learned by costly experiment. Pine tar has been highly recommended for wounded trees, but it has been known to kill young peach trees to which it was applied to keep away mice.

For nursery stock badly injured by mice there is no remedy. When the injury is slight the wounds may be covered with wax or soil and will heal over in a season, delaying sale for a year. This applies to both deciduous trees and evergreens. In the case of young trees, when the injury is considerable the tops may be cut out and new ones grown more quickly than fresh stock, but this is possible only when the wounds are well above the original graft. In the case of valuable or rare sorts bridge grafting may be resorted to, but for ordinary stock it is cheaper to pull up the injured trees and grow new ones.

SUMMARY.

Field mice, because of their small size, secretive habits, and great fecundity, often become a menace to farm and orchard crops in many parts of the country. In the Old World, as well as in America, corrective measures begun after a plague of the animals is in full progress have usually proved ineffectual. Preventive measures, if carefully carried out, are sufficient to avoid serious losses.

Among the more important measures for preventing ravages by field mice are the following:

1. Protection of the natural enemies of field mice, particularly owls, most hawks, shrikes, snakes, skunks, badgers, and most species of weasels.
2. Elimination of the breeding grounds of field mice by draining swamps and cleaning waste places that afford the animals harborage.
3. Periodic plowing of grass and other lands for the rotation of crops.
4. Clean cultivation of corn and all other crops, and especially of orchards and nurseries.

5. Clean mowing of grass lands and permanent meadows, so that no old grass is left over winter.

6. Careful burning about orchards and gardens of weeds, trash, and litter of all kinds that may serve the animals for winter shelter.

7. When necessary, the burning of dead grass in meadows and pastures. This, however, should not be delayed till late spring, when ground birds are nesting.

LITERATURE.

Readers of this bulletin who desire further knowledge of the classification and life history of field mice or of the historical accounts of their ravages, may, in addition to articles found in general works on mammals, consult the following:

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FOOD HABITS OF THE GROSBEAKS

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., November 1, 1907.

Sir: I have the honor to transmit herewith for publication as Bulletin No. 32 of the Biological Survey a report on the food habits of the grosbeaks, by W. L. McAtee. The grosbeaks are a small group of finches, hitherto more widely appreciated for their bright plumage, sweet song, and attractiveness as cage birds than for their services to agriculture. These are here shown to be of such character as to entitle the several members of the group to every consideration at the hands of the farmer.

The illustrations which accompany this paper are considered essential to a proper understanding of the text.

Respectfully,
H. W. Henshaw,
Acting Chief Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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FOOD HABITS OF THE GROSBEAKS.

INTRODUCTION.

Two distinct groups of finches or sparrows are commonly known as grosbeaks. One of these, which includes the pine and evening grosbeaks, is of little practical importance, since its members breed and pass most of their lives in mountainous regions, or in the northern parts of North America. The other group includes the cardinal, gray, rose-breasted, black-headed, and blue grosbeaks, which spend either the summer or the entire year within agricultural regions of the United States. Hence their food habits are of considerable importance to the farmer.

The members of the first-named group may be dismissed with the statement that during the period when they occur in non-mountainous districts their food consists largely of wild seeds and berries. Apparently the best relished are those of mountain ash, choke cherry, box elder, white ash, and maple, and of spruce, red cedar, and other coniferous trees. The food habits of the second group are treated in detail in the following pages.

CARDINAL.

(*Cardinalis cardinalis.* Plate I, Frontispiece.)

DISTRIBUTION AND HABITS.

The brilliant and easily recognized cardinal ranges over much of North America. It occurs from southernmost Mexico and northern Central America north to New York, Ontario, and northern Iowa, and west to central Kansas, Arizona, and Lower California. In parts of this area the size and color have been so modified by climatic and other causes that 12 varieties or subspecies are distinguishable. Five of these reside in the United States, and while they bear no distinctive vernacular names, the species as a whole is well supplied, being variously known as cardinal grosbeak or cardinal, Virginia nightingale, redbird, and also as the crested or topknot redbird, in distinction from the summer redbird or tanager.

The cardinal is resident wherever found; that is, the neighborhood where the bird rears its young is its home throughout the year. It is most abundant perhaps in the Southern States, where almost universally it is known as the redbird, and is often kept as a household pet. Affection for the bird, however, is not confined to the South, for its loud, ringing song, bright plumage, and vivacious manner make it a favorite wherever it lives. When winter's snows cover its favorite feeding grounds the redbird becomes bolder and seeks its fare about sheds and barns and even among the horses' feet. Spring returning, its natural food supplies are once more available, and then the cardinal mostly frequents hedges, fence rows, and brushy thickets. The cardinal is one of the few birds which sings throughout the year, although, of course, its songs are rendered more frequently and in greater perfection during the breeding season.

The nest is loosely built and generally is placed in a bush or vine, often in the densest tangles; in it three or four speckled eggs are laid. The first set of eggs usually is completed in May, but the second clutch is sometimes postponed until late summer. The cardinal is very sensitive to any interference in its domestic affairs, and unfinished nests and even those containing full complements of eggs are deserted upon slight provocation. Hence one who would have cardinals for neighbors must see to it that the birds' privacy is undisturbed. The male redbird is a model parent, rushing to the defense of the nest in every emergency, doing a great share of the feeding and otherwise caring for the young. The first birds of the year usually begin to shift for themselves about midsummer.

The nest of the redbird is often within a few feet of the ground, and this circumstance leads to the destruction of many sets of eggs and broods of young by snakes, cats, and prowling wild mammals. Hence the bird needs protection, and when this is afforded it easily maintains its numbers.

ECONOMIC RELATIONS.

As mentioned above, the cardinal has ever been a favorite cage bird, and in some localities in the south great numbers have been trapped and sold into captivity. In times past it has suffered greatly also from the persecution of millinery collectors. Despite legal enactments against the killing of birds for hat gear, even yet the practice has by no means ceased, and among other useful birds the cardinal still suffers to a greater or less degree. In the District of Columbia cardinals were noted on hats as late as 1906.

The extent of the former traffic in wild birds for cage purposes was remarkable. "Thousands of mockingbirds, cardinals, indigo birds, and other bright-plumaged species were formerly trapped for sale in this country and abroad, and so assiduously did the bird trappers ply their vocation that in some localities these species were almost exterminated."[a]

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[a] T. S. Palmer, Yearbook, Department of Agriculture, 1905, pp. 557–558.

Referring to the cardinal in particular. Nuttall[a] makes the statement:

> So highly were these birds esteemed for their melody that, according to Gemelli Carreri [who wrote in 1699], the Spaniards of Havana, in a time of public distress and scarcity, bought so many of these birds * * * that the sum expended, at ten dollars apiece, amounted to no less that 18,000 dollars.

The liking of the islanders for this bird has suffered no abatement in later days, according to W. E. D. Scott,[b] who wrote in 1889: "The cardinal is in great demand as a pet by the Cubans, and on that account is a regular feature of the auction rooms, being supplied from the northern keys and the mainland" [of Florida]. However, recent laws, while they have not wholly put an end to these baneful practices, have greatly restricted them, and the cardinal, along with other insectivorous birds, is nowadays comparatively well protected.

That from an economic standpoint the bird deserves complete protection, the following discussion of its food habits will make clear. Four hundred and ninety-eight stomachs of this species have been examined. They were collected during every month of the year and in twenty States, the District of Columbia, and Ontario. But for the fact that this material is unevenly distributed, seasonally and geographically, the results obtained from its examination would be perfectly satisfactory. As it is, Texas is much more completely represented than any other State, and May than any month, while the feeding habits for June and October are known only from examination of a very small number of stomachs. These conditions necessarily affect the results, but in view of the large number of stomachs, it is believed that a fairly correct idea of the normal food habits of the species has been obtained. As a result of our investigations it appears that, for each of the twelve months, the cardinal averages 28.99 percent of animal food and 71.01 percent of vegetable. The maximum percentage of animal food for any one month is 78.4, being the average for 123 birds taken in May. The minimum is 4.9 for 41 birds in January.

VEGETABLE FOOD.

It is generally stated that the cardinal is largely, if not entirely, vegetarian. While this statement is perhaps too strong, the result of the present investigation leaves no doubt that vegetable products compose the redbird's main subsistence at nearly all times of the year. In only one month do they constitute less than half the food, while for the entire year they average 71.01 percent. Grain amounts to 8.73 percent; wild fruit, only the seeds of which are usually eaten, composes 24.17 percent; weed and other seeds 36.38 percent, and miscellaneous vegetable substances 1.73 percent.

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[a] Manual of Ornithology, The Land Birds, 1832, p. 525.

[b] Auk. VI, 1889, p. 324, quoting Atkins.

GRAIN.

A little more than 7.1 out of a total of 8.73 percent of grain eaten by the cardinal grosbeak is corn, while other cereals, including wheat, oats, sorghum, and rice, constitute the remaining 1.62 percent. Eleven birds had eaten oats, 4 wheat, 2 sorghum, and 1 rice, but so trifling is the percentage of these grains that practically no damage is done except under very unusual conditions, such as the concentration of a great number of redbirds in a small area; but this is improbable, because the redbird usually is nongregarious.

In regard to corn, however, which was eaten by 68 of the birds examined, more extended consideration is desirable. The redbird's fondness for Indian corn is noted by many writers, but extensive injury to the crop is charged by very few. Leverett M. Loomis,[a] in writing of the birds of South Carolina, says the cardinal is "held in considerable ill repute because of its alleged depredations on newly planted corn." A correspondent in Alabama writes that the redbird is injurious to corn in the roasting-ear stage, and that it also "pulls the corn in the spring when it is just up with two or three leaves." Little direct evidence concerning the redbird's depredations on corn is derivable from our examinations, because none of the birds studied were collected in newly planted fields or where corn was exposed to attack. It should be stated, however, that during March, April, and May, which months cover the planting seasons from southernmost United States to Canada, less than the average amount of corn is consumed. Corn constitutes a greater proportion of the food in January than in any other month, and practically all eaten at this season is waste. So also in November and December, when corn makes up 4 and 7 percent, respectively. Waste grain is often eaten in spring and even in midsummer, according to observations by the writer.

The cardinal is said to bore into grain stacks and also to visit corncribs in winter, but probably it does so only under stress of unusual circumstances, as deep snow, and in all likelihood the damage is trivial. Lining the crib with medium-meshed wire netting, which can be done at small cost, will prevent access by the birds, and at the same time guard against attacks of rodents and poultry, while in no way interfering with the necessary ventilation.

Considerable corn is eaten by the redbird during June, July, and August, and a portion of this may be pilfered from the standing crop. At this season, however, the birds are scattered, and it is not likely that much damage results in any one locality.

From the above it appears that present evidence does not suffice to determine the exact relation of the redbird to the corn crop, although, so far as it goes, it is in the bird's favor. To summarize:

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[a] Auk. VII, 1890, p. 125.

Very few complaints have been made of attacks on corn by the redbird. Though this evidence is negative, it possesses some weight, since accusations against serious grain pests are always numerous and emphatic. The greatest proportion of corn is eaten in winter, hence is waste; and finally, the redbird does not flock habitually, and never at a season when corn is exposed to attack. For these reasons it may be concluded that the cardinal's depredations on corn are of little consequence.

WILD FRUIT.

Wild fruit, or rather the seeds of wild fruit, pulp being present in very few stomachs, was eaten by 312 of the redbirds examined, and, with the exception of weed seeds, is the largest item of the vegetable food. Of all fruits wild grapes are most important. From November to April their seeds constitute 17 percent of the cardinal's fare. They were eaten by 178 birds and in every month, forming on the average 11.9 percent of the subsistence throughout the year. Three species, the summer grape (*Vitis aestivalis*, Pl. II, fig. 8), the frost grape (*V. cordifolia*), and the bullace or southern fox grape (*V. rotundifolia*) were identified, and there is no doubt that the redbird feeds upon all kinds of wild grapes growing within its range. Although wild grapes are such favorite food, they seldom are swallowed whole, only one or two entire grapes being found in the stomachs. Further, very few entire seeds are swallowed. The seeds are generally crushed and ground by the powerful beak into such small bits that their identification is very difficult.

The presence of great numbers of fruit seeds with little or no pulp is accounted for by well-known habits of the bird. It searches continually among leaves and rubbish on the ground, where it secures many of the seeds and shriveled fruits. It also gathers dried berries from the vines in winter.

The fruits of various dogwoods rank next to grapes in the redbird's regimen. They were eaten by 52 birds and constitute 3.97 percent of the total food examined. Rough-leaved (Pl. II, fig. 6) and flowering dogwood (Pl. II, fig. 5) seeds were identified. Any one familiar with the intense bitterness of these fruits will admit that the cardinal possesses considerable individuality of taste.

All fruits united, other than cornel berries and grapes, form 8.3 percent of the annual food. Most important among them are blackberries and raspberries, which were eaten by 34 birds. Mulberries were eaten by 31, and hackberries by 23 redbirds. Among the latter fruits two species were identified—the common hackberry or sugar berry (*Celtis occidentalis*, Pl. II, fig. 2) and the southern hackberry (*C. mississippiensis*). The last named was eaten by nearly 20 cardinals collected in one locality in Texas. Smilax seeds, identified as of the bristly or bamboo greenbrier (*Smilax bona-nox*), which are almost as hard as wood, were taken by 2 individuals. It would be well for humankind if more birds were fond of the seeds of these detestable vines. One cardinal ate seeds of Solomon's seal (*Polygonatum biflorum*).

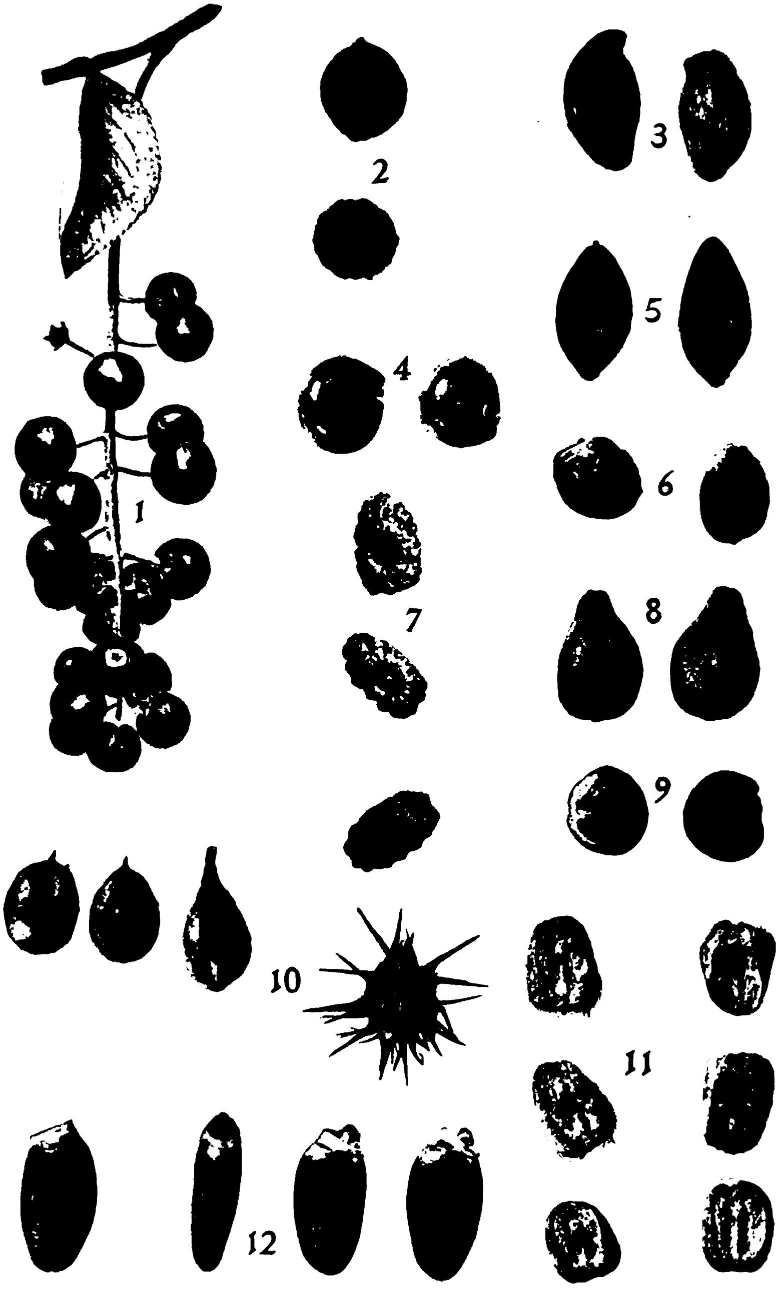
Cherries also are on the redbird's bill of fare. One correspondent states that redbirds filch cultivated varieties, but as none appeared in any of the stomachs examined, the occurrence probably is exceptional. Chokecherries are consumed, however, and Dr. A. K. Fisher has observed a cardinal eating the fruit of a seedling cherry (*Prunus avium*).

Wilson says cardinals feed upon the seeds of apples, but this habit also must be rare; in the course of the present investigation no cultivated fruit of any kind was found.

Six cardinals devoured blueberries (*Vaccinium* spp. including *V. virgatum*), three ate the aromatic berries of spice bush (*Lindera benzoin*), and 6 took the purple fruit of the pokeberry (*Phytolacca decandra*, Pl. II, fig. 4). The seeds of the succulent fruit of the prickly pear (*Opuntia opuntia*, Pl. II, fig. 9) were found in the stomachs of 3 cardinals, taken near the District of Columbia, where the plant abounds on the rocky banks of the upper Potomac. Six redbirds fed upon the drupes of sumac, including those of the poison ivy (*Rhus radicans*) and of the skunk bush (*Rhus trilobata*). These fruits are sometimes eagerly sought. The writer once in winter observed a scattering flock of 50 or more redbirds feeding on the berries of scarlet sumac.

The elderberry, which is so relished by the rose-breasted grosbeak, is rather neglected by the cardinal, only 2 having selected it. Two also ate ground cherries and black haws, while but 1 stomach contained rose hips, though the bird has often been observed devouring these fruits. Juneberries (*Amelanchier canadensis*, Pl. II, fig. 3) and others of the same genus are eaten; both holly (*Ilex opaca*) and inkberry (*I. glabra*) are occasionally secured, as well as red cedar berries (*Juniperus virginiana*), the fruit of the knockaway tree (*Ehretia elliptica*), and red haws (*Cratægus* sp.). In a stomach collected in South Carolina in January were more than 12 seeds of the berry of the passion flower (*Passiflora incarnata*). To the above list of fruits eaten by the cardinal, various authors add the wahoo berry (*Euonymus* sp.), Mexican mulberry (*Callicarpa americana*), and drupes of the cabbage palmetto (*Sabal palmetto*) and saw palmetto (*Serenoa serrulata*).

Among many items of vegetable food to be classed as miscellaneous are some of particular interest. Acorns were eaten by a few cardinals and one bird even selected a hickory nut. The strength of bill necessary to shear into such hard seeds may be imagined, and it



SEEDS AND FRUITS EATEN BY GROSBEAKS.

[1, Wild black cherry (*Prunus serotina*). 2, Hackberry (*Celtis occidentalis*). 3, Juneberry (*Amelanchier canadensis*). 4, Pokeberry (*Phytolacca decandra*). 5, Flowering dogwood (*Cornus florida*). 6, Rough-leaved dogwood (*Cornus asperifolia*). 7, Spiderwort (*Tradescantia virginiana*). 8, Summer grape (*Vitis æstivalis*). 9, Indian fig (*Opuntia opuntia*). 10, Bur grass (*Cenchrus tribuloides*). 11, Button weed (*Diodia teres*). 12, Milk thistle (*Mariana mariniana*). 1, Natural size; 2, 5, 9, 10 (bur), magnified twice; 6, 7, 8, 11, 12, magnified three times; 3, 4, 10 (seeds), magnified four times.]

is noteworthy that the cardinal appears to be the only one of the grosbeaks which uses its massive beak for the purpose for which it seems especially designed, namely, the cracking and grinding of hard seeds. The samaras of maple were found in a few stomachs, and in Florida Mr. C. J. Maynard[a] observed more than 20 cardinals feeding on the seeds of a single maple. The somewhat similar winged seeds of the tulip tree also serve as food, and, according to the experience of the writer, are a favorite winter diet of the redbird around Washington. Galls were eaten by 4 birds, and buds, which often have been stated to be especially sought after by grosbeaks, by only 2.

WEEDS.

The seeds of bindweeds, grasses, sedges, etc., form 36.38 percent of the entire food—more than half of the vegetable diet of the species. They were eaten by 361 of the birds examined, and range from 6 to 49 percent of the fare in different months, the greatest quantity being consumed in winter. The seeds of the various smartweeds (fig. 1) and bindweeds (fig. 21) are of most importance, having been consumed by 81 cardinals and constituting 5.57 percent of the annual food. Six species were identified, and it is probable that the seeds of all members of this large genus are eaten indiscriminately. They are among the commonest and worst weeds of both dooryards and cultivated fields. Besides being notorious crop chokers and seed adulterants, smartweeds are the main support of the disastrous corn-root aphids before the latter are transferred to the corn by their ant guardians. Hence the cardinal's habit of devouring smartweed seeds is beneficial, not only in abating direct injury by these pernicious weeds but also in tending to diminish the number of aphids by destroying their most important host plants.

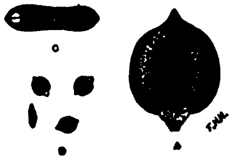


FIG. 1.—Seeds of smartweed (*Polygonum lapathifolium*). (From Hillman, Nevada Experiment Station.)

The seeds of foxtail grasses (figs. 17 and 37) are next in importance. Foxtail is only too well known for its keen competition with cultivated crops, and is to be classed among the most troublesome weeds. Its seeds compose 3.21 percent of the cardinal's food, 51 out of 498 birds examined having eaten them. Bur grass (*Cenchrus tribuloides*, Pl. II, fig. 10) should be mentioned here, as it is possible some of its seeds were wrongly classed with those of foxtail, the shelled kernels of which they greatly resemble. They have been positively identified in several stomachs. Henry Nehrling[b] says cardinals "are very fond of bur grass seeds or sand spurs * * *

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[a] Birds of E. N. A., 1881, p. 109.

[b] Our Native Birds of Song and Beauty, II, 1896, p. 196.

which are furnished with formidable spines. This grass is a very vile weed of the southern fields and the orange groves of Florida."

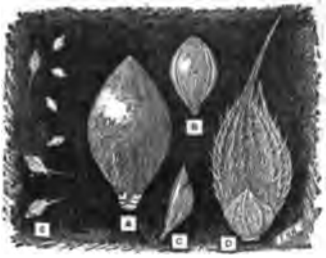

Fig. 2.—Seeds of cockspur grass (*Echinochloa crus-galli*). (From Hillman, Nevada Experiment Station.)

The seeds of other grasses, including cockspur grass (*Echinochloa crus-galli*, fig. 2), crab grass (*Syntherisma sanguinalis*), and allied species, which are well-known weeds, were fed upon by 31 redbirds, yard grass (*Eleusine indica*) by 31, and unidentified grasses by 22.

Seeds of the nearly related sedges (*Carex* et al.) were devoured by 41 cardinals, those of vervians (*Verbena hastata*, fig. 3, and *V. urticæfolia*) by 25. Twenty-two birds ate seeds of the well-known ragweeds (fig. 6), and 39 those of various spurges.

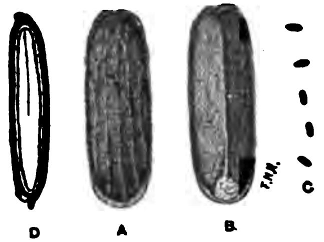

Fig. 3.—Seeds of blue vervain (*Verbena hastata*). (From Hillman, Nevada Experiment Station.)

Among the other weed seeds eaten in smaller quantities are those of dodder, a serious pest in grain crops; vetch, dock, sow thistle, plantains, including the detestable ribgrass (fig. 4); tumbleweed (fig. 18), sunflower, violets, geraniums, stargrass, spiny sida, corn gromwell (fig. 5), spiderwort (Pl. II, fig. 7), lamb's-quarters, chickweed, stick-tight, sorrel, button weed (Pl. II, fig. 11), and stick-seed. To this list W. D. Doan adds clover and partridge pea.[a] One plant in the above list, namely, buttonweed, is known also as alligator head in the South, where it is a bad weed in rice fields. It has been said that "as the seeds are about the color of the soil they are not easily seen and are not apt to be picked up by birds." This is a mistake, however, for these seeds are devoured by many kinds of birds, and some, as the bobwhite, eat large numbers of them.

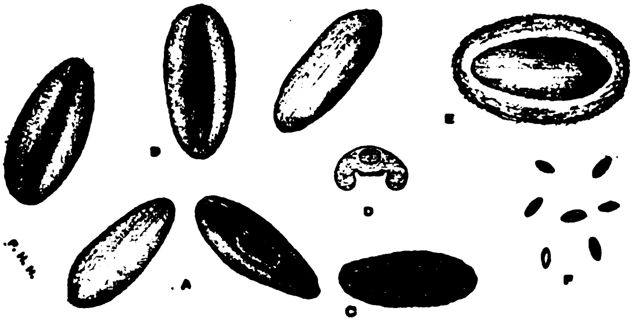

Fig. 4.—Seeds of ribgrass (*Plantago lanceolata*). (From Hillman, Nevada Experiment Station.)

After plants have seeded it is impossible for man appreciably to diminish the number of seeds. But this work is the peculiar function of seed-eating birds, and their great value to the farmer consists in the service they render in this direction. The warfare against seeds, so costly to him, is waged by the whole body of sparrows and other seed-eating birds year in and year out without cessation. Were it not for them the number of weeds would be vastly greater and the resulting damage correspondingly larger. How great this damage is will appear from the statement that the loss to the wheat interests of Minnesota from dockage, largely due to the presence of weed seed, is about $2,500,000 annually.[a] Moreover, conditions in Minnesota are not exceptional, and in every State the total annual loss from weed seeds is very great. So far, then, as farmers can protect and increase the number of weed-seed eating birds to that extent will they reap the benefit of increased service from these faithful servants. The redbird eats the seeds of many of the most harmful weeds, making more than a third of its subsistence upon them. Hence it occupies a very important place among the weed-destroying birds, and should be prized accordingly.

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[a] Bull. 3, Agr. Exp. Sta., W. Va., 1888, p. 74.

FIG. 5.—Seeds of corn gromwell (*Lithospermum arvense*). (From Hillman, Nevada Experiment Station.)

ANIMAL FOOD.

Though in quantity much less than the vegetable food, the animal portion of the cardinal's diet is much more diverse and is comprised in no less than six of the natural classes. These are myriapods, centipedes, insects, spiders, bivalves, and univalves. Insects are vastly more important than the others and constitute 26.25 out of 28.99 percent, the total proportion of animal matter consumed. The percentage is apportioned among the orders of insects as follows: Wasps 0.92, bugs 3.72, butterflies (and caterpillars) 5.1, grasshoppers 6.42, and beetles 10.48.

FIG. 6.—Seeds of ragweed (*Ambrosia artemisiaefolia*). (From Hillman, Nevada Experiment Station.)

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[a] Bull. 95, Minn. Agr. Exp. Sta., 1906, p. 195.

The last-named group includes two mainly beneficial families, the ground beetles (Carabidæ) and the fireflies (Lampyridæ). Since the destruction of these beetles by the cardinal tends to neutralize the good done in other ways, it is important to understand thoroughly the nature of the bird's relation to them. Among the most beneficial of beetles are the caterpillar hunters (*Calosoma*, fig. 7), which ascend trees in quest of their prey, a rare habit among ground beetles. Thus these beetles attack caterpillars in a way others are unable to do. Two cardinals ate beetles of this genus. Another large carabid (*Pasimachus*), an enemy of grasshoppers and the army worm, was eaten by one redbird. Others devoured include *Harpalus caliginosus*, which is the bulky black beetle often seen feeding on the flowers of ragweed and which is evidently not entirely predaceous, and a larva of the nearly related beetle *Dicœlus*. Three birds captured individuals of the medium-sized but very hard *Scarites subterraneus*, which generally hides under stones by day. Specimens of two species of *Anisodactylus* and one beautiful blue *Callida* also were eaten. In all 34 redbirds fed upon beetles of this useful family, but each must have eaten sparingly, for the beetles compose but 0.75 percent of the entire food, an amount too small to be reckoned against the consumer of more than 8 times that quantity of grasshoppers, in addition to many other injurious insects.

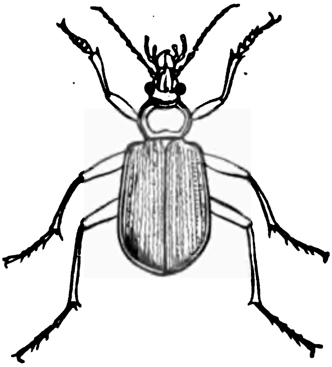

FIG. 7—Caterpillar hunter (*Calosoma scrutator*). (From Riley.)

Fireflies were eaten by only 4 cardinals, one of the birds obtaining the common black and yellow soldier beetle (*Chauliognathus marginatus*), which commonly feeds on the pollen of midsummer blossoms, and another, one of the small black fireflies (*Telephorus pusillus*), the larvæ of which are enemies of some common agricultural pests. Fireflies are eaten in such moderate measure that it is impracticable to assign them a percent, and we may conclude, so far as the present data go, that the cardinal does no appreciable injury to this group of insects.

The wasps and similar insects (Hymenoptera) include among their number many beneficial parasitic species, and for that reason their status as food of the redbird must be looked into. Fifty-nine of the grosbeaks examined had eaten these insects, but they amount to only 0.92 percent of the total food. None were positively identified as parasitic species, while some injurious forms were distinguished. Eleven cardinals ate ants, including the harvesting ants (*Pogonomyrmex*) and the small reddish *Lasius*, which foster plant lice, notably the corn root aphids. One grosbeak ate a sawfly, which also is an insect of unsavory reputation.

The cardinal is frequently alluded to in ornithological literature as preying upon bees. Peter Kalm published the first of these statements in 1770, and the later ones were probably suggested by, if not copied from, his. Wilson (1831), Nuttall (1832), and later authors reiterate the charge, though the context does not show that any of them knew of the matter at first hand. It is quite possible that, so far as this particular trait is concerned, the cardinal has been confounded with the similarly colored but otherwise very different summer redbird, which is well known to prey upon bees. At any rate, it is significant that the present examination did not reveal a single bee among the insect food of the redbirds. On the whole, the cardinal shows no great relish for Hymenoptera, and among the species eaten those injurious to man and the less valuable kinds predominate.

Among other possibly beneficial insects, the redbirds had eaten an assassin bug and a remarkable predaceous neuropteron (*Mantispa brunnea*), also a nymphal and an adult dragon fly. The latter creatures probably do as much harm in destroying young fish as good in preying upon insects. At most, not more than 2 percent, probably much less, of the cardinal's food consists of useful insects, while 12 times as much consists of injurious species, the destruction of which is a benefit.

One of the most important constituents of the major proportion is Lepidoptera. They compose 5.08 percent of the annual subsistence, amounting, however, in May to 26.71 percent. The adults taken consist of 5 moths and 1 butterfly, which together make up 0.17 percent of the food. Caterpillars are much more relished and 137 redbirds fed upon them, sometimes obtaining from 7 to 18 each. The cotton worm (*Alabama argillacea*, fig. 20), which formerly was a serious pest and which even now spoils a late-planted crop, was eaten by 3 cardinals. There is evidence that the bird habitually feeds upon this insect, and as early as 1885 C. V. Riley remarked[a] that "birds are of incalculable benefit" in combating the cotton worm, and the cardinal is one of those which prey upon it more or less persistently.

A second cotton pest, the bollworm (*Heliothis obsoleta*, fig. 8), which is familiar also as the corn ear-worm, is occasionally devoured, and a third, the cotton cutworm (*Prodenia ornithogalli*, fig. 9) is greatly relished. Ninety-six of the latter were eaten by 31 cardinals from the Texas cotton fields. The destruction of cotton insects by the redbird is important, since the bird is numerous in the cotton region and feeds upon the worst enemies of the plant.

The sphinx caterpillars, so many of which are injurious to cultivated plants, were eaten by 20 redbirds. The species identified are the laurel sphinx (*Sphinx kalmiæ*) and the purslane sphinx (*Deilephila lineata*, fig. 38), the latter being a general feeder and attacking several garden and field crops. Measuring worms were eaten by 2 cardinals, the zebra caterpillar (fig. 10) of the cabbage by 1, while 2 secured chrysalides of the notorious codling moth. It thus appears that the lepidopterous food of this grosbeak contains a number of serious pests, and the bird accomplishes much good by destroying them.

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[a] Fourth Ann. Rep. U. S. Ent. Comm. 1885, p. 88.

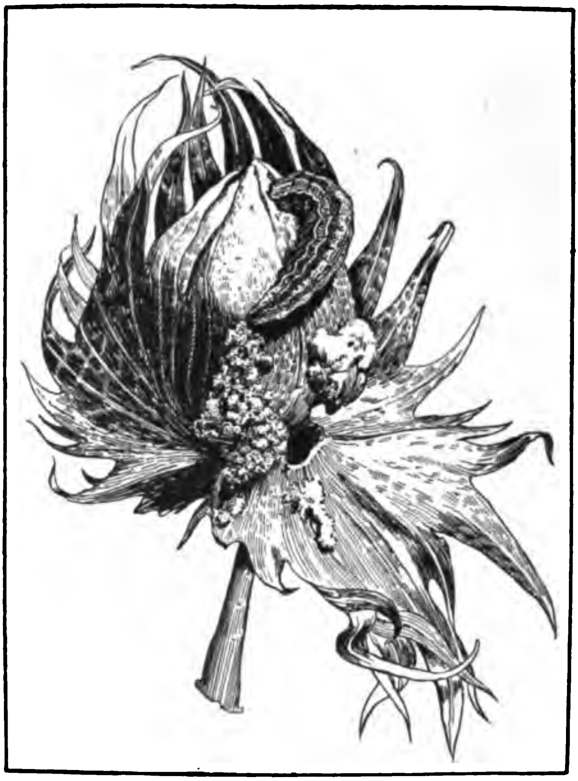
FIG. 8.—Bollworm or corn-ear worm (*Heliothis obsoleta*). (From Quaintance, Bureau of Entomology.)

A somewhat larger number of cardinals than ate caterpillars preyed upon grasshoppers, and these insects form a correspondingly larger proportion of the food, namely 6.43 percent. Crickets and long and short horned locusts were eaten and a decided taste for the eggs of katydids is shown, they being consumed by 21 redbirds. Among the short-horned grasshoppers the small shield-back grouse locusts were taken, and also the lesser migratory locusts (*Melanoplus atlanis*, fig. 39), which during the invasions of the Rocky Mountain grasshopper was second only in importance to that formidable insect. The cardinal did its share in repelling the locust hosts in the seventies, Mr. Aughey, of Nebraska, finding more than 20 locusts per bird during his examinations. It is certain that the redbird's aid in restricting the less conspicuous pests of the present day is no less valuable.

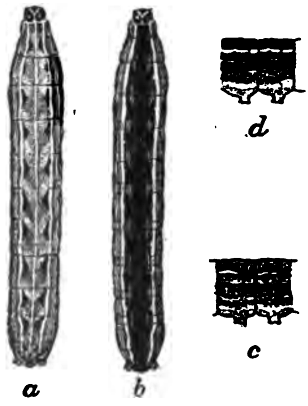

FIG. 9.—Cotton cutworm (*Prodenia ornithogalli*). (From Chittenden, Bureau of Entomology.)

Other insects bearing the name "locusts," but not at all closely related to the grasshoppers, belong to the order Hemiptera, which furnishes 3.72 percent of the cardinal's subsistence. These dogday locusts, harvest or jarflies, which injure the twigs of trees, are, on account of their loud, vibrating song, among the best-known insects. Their great size would seem to prevent most birds from capturing them, but 9 of the redbirds examined had accomplished the feat. The common harvest fly (*Cicada tibicen*, fig. 11) was identified from two stomachs, and according to A. W. Butler[a] the seventeen-year locust (*Tibicen septendecim*) also is eaten by the redbird.

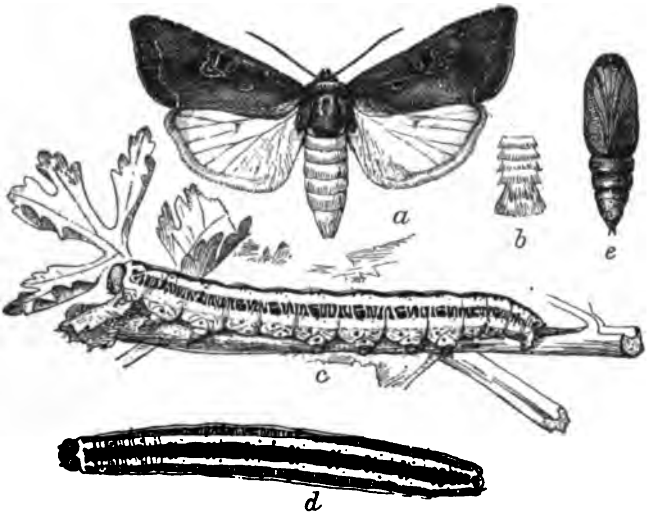

Fig. 10.—Zebra caterpillar (*Mamestra picta*). (From Chittenden, Bureau of Entomology.)

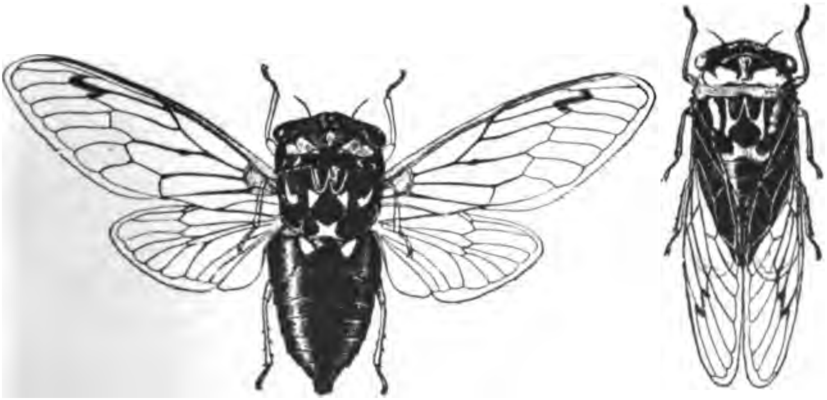

Fig. 11.—Harvest fly (*Cicada tibicen*). (From Lugger, Minnesota Experiment Station.)

Several insects of this order are miniatures of the cicadas, such as the jumping plant-lice (Psyllidæ) and leaf-hoppers (Tettigonidæ).

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[a] Bull. 12, Div. Ent., 1886, p. 30.

These and the curiously shaped tree-hoppers (Membracidæ), all of which are more or less injurious, are occasionally taken by the redbird. More often this grosbeak secures the tiny bark-lice or scale insects (Coccidæ). These minute but nevertheless destructive pests, which have not long been known to be preyed upon to any extent by birds, were devoured by 21 cardinals. The cherry scale (*Eulecanium cerasifex*), which is sometimes injurious, was identified from one stomach, while another contained scales which are probably the locust bark-scale (*E. robiniarum*). Other scale insects of the same genus were fed upon by 15 cardinals and those of a related genus (*Toumeyella*) of the southeastern United States by 2.

Other Hemiptera were eaten by 59 grosbeaks, 31 selecting the vile-smelling stinkbugs (Pentatomidæ), including the green tree-bug (*Nezara hilaris*) and 1 specimen of *Euschistus*. The secretions of the latter insect have proved fatal to such hardy creatures even as weevils, but apparently they do not daunt the cardinal. One assassin bug and 1 species of the chinch-bug family also were devoured. Practically all of the Hemiptera eaten are injurious, and some, such as the scale insects, extremely so. Consequently, the cardinal's habit of preying upon them is highly beneficial.

Passing to beetles, we find weevils are eaten to a greater extent than any others. These compactly formed snout-bearers belong to 10 families, members of 3 of which are preyed upon by the cardinal. Most of the weevils attack nuts, fruits, and seeds, including those of cultivated plants. Hence, they are generally harmful and many kinds are exceptionally destructive. Weevils often are obscurely colored and have the habit of feigning death, but notwithstanding these protective devices they are captured in large numbers by all insectivorous birds. One hundred and fifty-seven cardinals ate weevils in quantity sufficient to make 3.26 percent of the food of all examined. Scarred snout-beetles and curculios are equally relished. Sixteen redbirds fed upon a species (*Compsus auricephalus*) of the former group, which, in the adult state, occurs upon the leaves of cotton. The tiniest fragment of this insect suffices for identification, because of the beautiful covering of silvery green and golden scales. Thirteen other grosbeaks ate scarred snout-beetles which can not be identified. Of curculios, the acorn weevil (*Balaninus nasicus*), with a snout almost as long as the body, and several species of 5 weed-mining genera were captured. Six redbirds ate the injurious clover weevils (*Sitones*). The cotton boll weevil (fig. 19) also is occasionally eaten by the cardinal, 2 of the present collection having secured specimens of this highly destructive insect. Twelve redbirds captured curculios which were not further determined. Bill-bugs (fig. 12), which as larvæ live in the roots of grasses or sedges and as adults often injure corn by drilling holes in the stems of young plants, were devoured by 13 cardinals. Two species (*Sphenophorus cariosus* and *S. compressirostris*) were identified.

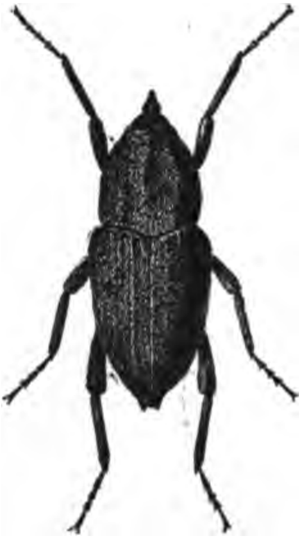

Fig. 12.—A bill bug (*Sphenophorus*). (From Forbes, Illinois Experiment Station.)

Lamellicorn or scarabæid beetles are next in importance to weevils in the beetle diet of the cardinal. They were eaten by 77 birds and compose 2.56 percent of the annual food. Many of them feed on excrementitious matter and are of neutral economic significance; but few of these are consumed by the bird. Those secured include the common road-frequenting dung beetles, which were captured by 6 cardinals, and the large resplendant scavenger *Phanæus carnifex.*

Other species in this family, however, are not so harmless as the above. The spotted vine-chafer (*Pelidnota punctata*), which is an important grape pest in the eastern United States, the two-spotted *Anomala*, which also devours the foliage of the grape, and the cetonias (*Euphoria inda*, fig. 15; *E. fulgida*, et al.), which feed upon all sorts of flowers and sometimes on young Indian corn, are all accepted as food by the cardinal. The southern june beetle or figeater (*Allorhina nitida*, fig. 13), which causes considerable damage in Florida and neighboring States, was found in a few stomachs; but since the cardinal evinces a strong preference for large insects and abounds in this beetle's favorite home, many of them, no doubt, are devoured. Of greatest interest in this family are the rose-chafers (*Macrodactylus subspinosis*, fig. 14.) These beetles are so abundant at times, says Prof. J. B. Smith, that they " ruin not only vineyards, but orchards and gardens, eating every kind of fruit and flower;

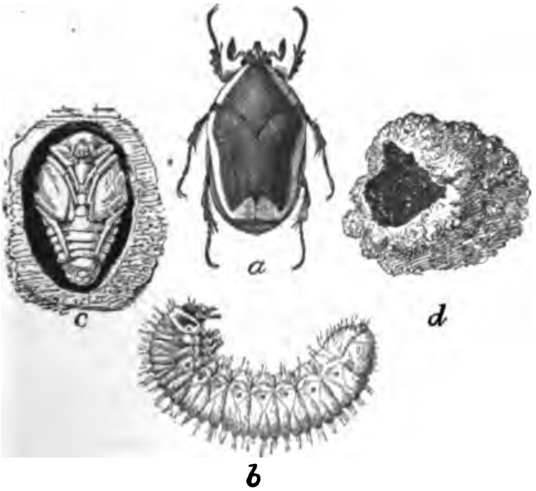

Fig. 13.—Figeater (*Allorhina nitida*). (From Howard, Bureau of Entomology.)

two or three days suffice to ruin a vineyard." These insects have very long and spiny legs, and opinions differ as to whether birds eat them, some affirming that they do, others that they do not. As a matter of fact, they are preyed upon by several wild birds, including the yellow-billed cuckoo, crow blackbird, kingbird, phoebe, green-crested flycatcher, redheaded woodpecker, and cardinal, the last-named being one of the most important of their enemies. Four of the birds examined during the present investigation had eaten rose-beetles, each of them taking several, and on July 5, 1906, the writer watched a brood of young which were being fed rose-chafers, remains of 17 being recovered from ejecta. These facts indicate that the cardinal is so fond of the rose-beetle as to capture it whenever possible. This habit of the bird, together with its inroads upon the vine-chafers of the family, are of considerable economic importance.

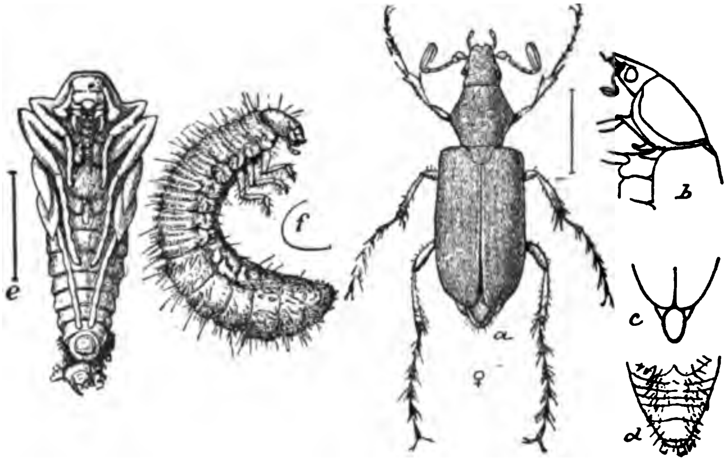

FIG. 14.—Rose beetle (*Macrodactylus subspinosus*). (From Riley, Bureau of Entomology.)

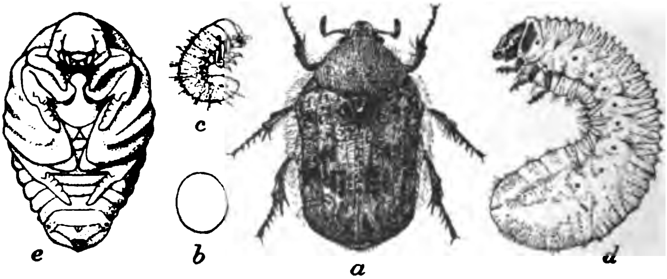

FIG. 15.—Flower eating scarabæid (*Euphoria inda*). (From Chittenden, Bureau of Entomology.)

Next in importance among beetles in the diet of the cardinal grosbeak are the bronzy wood-borers (Buprestidæ), which compose

1.17 percent of the subsistence, being eaten by 31 birds. In the larval state these beetles excavate tunnels in trees and do immense damage. Two species were identified in stomachs of the redbird, namely, the locust borer (*Agrilus egenus*) and another (*Dicerca obscura*) which bores into various deciduous trees. The beetles of this family seem to be a regular item of diet of all kinds of grosbeaks, and we may be sure that their destruction is highly beneficial.

The rather similar appearing click-beetles, adults of the disastrous wireworms, were secured by 23 redbirds. Twelve birds ate long-horned borers (Cerambycidæ), 2 species being identified, neither of which is an important pest. However, the entire family is injurious, and the cardinal should be commended for diminishing the numbers of any of the species.

The closely related family of leaf-beetles (Chrysomelidæ) does not furnish a large percentage of the redbird's fare, although several of its species are captured. The notorious spotted cucumber-beetle (*Diabrotica 12-punctata*, fig. 26), the strawberry root-borer (*Colaspis brunnea*), plum leaf-beetle (*Nodonota tristis*), sweet potato leaf-beetle (*Coptocycla*), willow and poplar species (*Chrysomela bigsbyana* and *Melasoma scripta*), besides some others that feed on weeds and other wild plants, are occasionally eaten. Two additional species, the locust leaf-miner and the three-lined potato beetle, deserve more extended notice. Concerning the locust leaf-mining beetle (*Odontota dorsalis*, fig. 16), Dr. S. D. Judd says, in "Birds of a Maryland Farm:"[a]

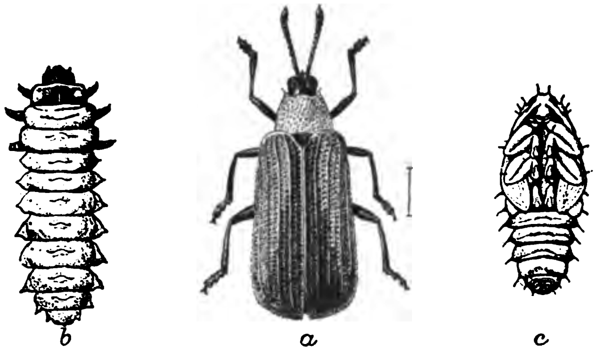

FIG. 16.—Locust leaf-miner (*Odontota dorsalis*). (From Chittenden, Bureau of Entomology.)

> In the summer of 1895 a destructive outbreak * * * turned all the locusts of the farm as brown as if they had been scorched by fire, ruining the verdure of the river bluff. * * * From 1896 to 1902, inclusive, the beetles did not again ruin the foliage. * * * In 1896 the trees further up the river, however, were turned brown, showing that the escape of those at Marshall Hall was not due to climatic conditions unfavorable to the insects; therefore it is possible that the birds were at least to some extent responsible for it.

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[a] Bull. 17, Biological Survey, 1902, pp. 29–30.

The cardinal is one of the birds which assisted in checking this infestation. Two individuals taken at the time had eaten leaf-miners, one having secured no fewer than 10.

Before the advent of the Colorado beetle, a smaller leaf-beetle (*Lema trilineata*), which naturally feeds on ground cherries (*Physalis*), turned its attention to potatoes and made itself widely known. Even at present it is by no means harmless in the Southern States. It is encouraging, therefore, to know that the cardinal seems to relish the species, one bird collected in Florida having eaten 14 of them. The cardinal has been reported to feed upon the genuine potato beetle also, by E. B. Williamson[a] and F. H. Chittenden.[b] Thus while not preying extensively upon the Chrysomelidæ, the redbird at times renders valuable service by eating some of the pests so numerous in the family.

The cardinal occasionally captures a few other kinds of beetles, such as the darkling beetles (Tenebrionidæ) noted for their nauseous secretions, and the blister beetles (Meloidæ), the fluids of whose bodies are highly vesicatory.

But few additional insects are consumed. One cardinal had eaten a two-winged fly, a member of an order the individuals of which are perhaps more abundant than those of any other, yet which is surprisingly exempt from the attacks of birds. Three redbirds devoured fragile mayflies of the kinds that often swarm about the lights of cities. They sometimes eat the larger kinds also, as was observed by Dr. A. K. Fisher, July 4, 1906, when a male cardinal was seen carrying in its beak one of the large dark mayflies (*Hexagenia bilineata*).

Belonging, together with the insects, to the subkingdom of the jointed animals (Arthropoda) are the spiders and centipedes, which in a small way contribute to the fare of the cardinal. One bird had eaten a centipede, while 22 obtained spiders or their egg sacs.

Snails and other mollusks were eaten by a great many of the birds examined, namely 112. Whether they were taken for grinding material or for food is a question, but the latter seems more likely in view of the large number devoured. One grosbeak had eaten several small bivalve shells which must have been obtained from water, and another secured a large slug.

The following note by D. E. Lantz shows that occasionally vertebrates serve as food.[c]

> December 27 [1884], while hunting, I saw a male cardinal grosbeak eating a field-mouse. Several others attempted to take it from him, but were unsuccessful. At my approach they left it lying on the snow. It was about half consumed.

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[a] Proc. Columbus Hort. Soc., XIII, 1898, p. 42.

[b] Circular 87, Bureau of Entomology, 1907, p. 12.

[c] O and O., X, 1885, p. 29.

MINERAL MATTER.

Mineral matter taken for grinding purposes, among which were many bits of cinder in addition to the usual quartz fragments and sand, averaged 5.7 percent of the gross contents of the stomachs examined.

NESTLINGS.

The nestlings of the cardinal, in common with those of most birds, are highly insectivorous. During the preparation of this report 4 have been examined, with the result that 94.75 percent of their food was found to be animal matter and 5.25 vegetable. Two of the number were young, just out of the nest, and they had consumed the vegetable substances; 2 were nestlings, and their diet was entirely animal. The stomach of one of the latter contained the thorax of a large cicada, and that of the other the remaining portions of that luckless insect. Both had been fed caterpillars—purslane (fig. 38) and laurel sphinxes—and each contained grasshoppers and spiders. A few larvæ and eggs of other insects also were in their stomachs. One of the young, just out of the nest, had been given a cicada, and, in addition, some 9 grasshoppers, a snail, and a few seeds, while the other had eaten lamellicorn beetles, weevils, and blackberry seeds. The proportions of the principal food items of the four nestlings are as follows: Cicadas, 17.25 percent; grasshoppers, 20; caterpillars, 21.25; and beetles, 23.25. Two other fledgelings in the collection had only a few bits of snail in their stomachs.

Observations upon nestling birds in the field being recognized as valuable in supplementing data obtained from the examination of stomachs, an effort was made throughout the season of 1906 to locate and thoroughly study a grosbeak family. Owing to various vicissitudes, satisfactory observations were made upon only one nest. Fifty-six trips by the parents were made to this nest in six and one-half hours, an average of 8.6 an hour. The young were fed 178 times, an average of 89 each. The longest interval between visits was thirty-five minutes, the shortest two.

The character of the food could not be determined by observation, but it was learned in another way. None of the excrement was removed from the box, whereas the nest in which the youngsters had been reared was kept perfectly clean. The fecal matter was dried and examined, and while by no means all of its constituents could be identified, enough was learned to indicate that the study of excreta is a very satisfactory method of determining the food of nestling birds. The nest of any fairly bold bird may be kept under surveillance and the waste matter collected before the parents remove it. The extent of the information as to the food eaten by the young to be obtained in this way is astonishing.

For instance, a single casting of a young cardinal, covered with its thick, chalky, and gelatinous layers, was preserved, and from it were taken the following: One insect egg, the leg and scutellum of a scarabæid beetle, head and other remains of a leaf-hopper, bits of a snail, and 11 seeds and the core of a mulberry. From the remainder of the total quantity the following were identified: Seventeen rose-beetles (*Macrodactylus subspinosus*, fig. 14), 2 other scarabæids, 1 click beetle (*Limonius* sp.), 1 caterpillar hunter (*Calosoma scrutator*, fig. 7), 1 leaf-hopper (Jassidæ), 3 grasshoppers, 1 spider, 1 dragon fly, many bits of snail, 17 blackberry seeds (*Rubus* sp.), and 221 seeds of mulberry (*Morus rubra*). The only beneficial species in the above list is the caterpillar hunter, while among the injurious forms, four in number, the rose-beetle is very important. This insect's habits, as well as its occasional overwhelming abundance, have been described on a preceding page.

The infestation of the insect about the District of Columbia in 1906 was especially severe. Not only roses were attacked by the insects, but elder blossoms were covered, and around the basswoods their humming was as loud as of a swarm of bees. Frequent attempts were made to discover whether the cardinal feeds upon them, but no opportunity was afforded until the above-mentioned nestlings were discovered at the extreme end of the rose-beetle season. The fact that so many were taken at that time is good evidence that special search was made for them.

Among the food given to the inmates of a nest under observation in 1907, the following were identified by sight: A chrysalis, a caterpillar or sawfly larvæ, a horsefly, and a grasshopper. From a small quantity of excrement were recovered bits of snail, grass seed, a small caterpillar, ground and click beetles, and 3 rose-beetles. The capture of the latter is again significant, as they were very scarce up to that time. This fondness for rose-beetles distinguishes the bird as an important guardian of the plants the insects attacks.

SUMMARY.

Examination of nearly 500 stomachs of cardinals shows that the bird's diet is about three-tenths animal and seven-tenths vegetable.

The cardinal has been accused of pilfering certain grains, notably corn, to an injurious extent, which charge the evidence from stomach examination neither proves nor disproves. But in view of the fact that only 8.73 percent of the total food is grain, and that more than half of that amount is waste, the loss is greatly overbalanced by the destruction of weed seeds alone, which compose more than half of the vegetable food. Moreover, some of the weeds consumed are especially destructive to grain crops.

In securing its insect food the cardinal injures us in 1 case and benefits us in 15. In other words, considering the animal food alone, only 1 cardinal does harm to 15 which do good. The presence of this single harmful bird among so many beneficial ones no more justifies us in classing the species as injurious than would a like proportion of disabled men justify the condemnation of a whole regiment.

On the contrary, since the cardinal, by its general food habits, does at least 15 times more good than harm, it must be classed among the very useful species. The following list of important pests the bird has been shown to prey upon is in itself sufficient proof of the cardinal's value. The list includes the Rocky Mountain locust, 17-year cicada, potato beetle, cotton worm, bollworm, cotton cutworm, cotton-boll weevil, codling moth, rose-beetle, cucumber-beetle, fig-eater, zebra caterpillar, plum scale, and other scale insects. A host of minor insect pests are attacked and the seeds of many noxious weeds are destroyed. The cardinal much more than pays its way, and deserves and should receive strictest protection. The bird is easily attracted by food in winter and by the provision of suitable nesting sites in summer. Being thus responsive to human care, and being so valuable economically, the cardinal's presence on the farm, and even in the city garden, should be encouraged in every possible way. With proper protection and encouragement it will become more and more numerous and render husbandry a correspondingly increased amount of useful service.

LIST OF SEEDS, FRUITS, AND INVERTEBRATES EATEN BY THE CARDINAL.

GRAIN.

Corn (*Zea mays*).
Rice (*Oryza sativa*).
Kafir corn (*Sorghum vulgare durra*).
Oats (*Avena sativa.*)
Wheat (*Triticum vulgare*).

WILD FRUITS.

Red cedar (*Juniperus virginiana*).
Solomon's seal (*Pologonatum biflorum*).
Bristly greenbrier (*Smilax bona-nox*).
Hickory (*Hicoria* sp.).
Oak (*Quercus* sp.).
Southern hackberry (*Celtis mississippiensis*).
Hackberry (*Celtis occidentalis*).
Mulberry (*Morus* sp.).
Pokeberry (*Phytolacca decandra*).
Tulip tree (*Liriodendron tulipifera*).
Spicebush (*Lindera benzoin*).
Blackberry (*Rubus* sp.).
Rose (*Rosa* sp.).
Juneberry (*Amelanchier canadensis*).
Red haw (*Cratægus* sp.).
Cherry (*Prunus* sp.).
Skunk bush (*Rhus trilobata*).
Poison ivy (*Rhus radicans*).
Holly (*Ilex opaca*).
Inkberry (*Ilex glabra*).
Maple (*Acer* sp.).
Summer grape (*Vitis aestivalis*).
Frost grape (*Vitis cordifolia*).
Bullace grape (*Vitis rotundifolia*).
Maypop (*Passiflora incarnata*).
Prickly pear (*Opuntia opuntia*).
Rough-leaved cornel (*Cornus asperifolia*).
Flowering dogwood (*Cornus florida*).
Blueberry (*Vaccinium virgatum*).
Knockaway tree (*Ehretia elliptica*).
Nightshade (*Solanum* sp.).
Elder (*Sambucus* sp.).
Arrowwood (*Viburnum* sp.).

WEEDS.

Large crab grass (*Syntherisma sanguinalis*).
Barnyard grass (*Echinochloa crus-galli*).
Yellow foxtail (*Chætochloa glauca*).
Bur grass (*Cenchrus tribuloides*).
Wire grass (*Eleusine indica*).
Sedge (*Carex* sp.).
Spiderwort (*Tradescantia* sp.).
Rush (*Juncus* sp.).
Star grass (*Hypoxis hirsuta*).
Star grass (*Hypoxis juncea*).
Dock (*Rumex* sp.).
Knotgrass (*Polygonum aviculare*).
Pale persicaria (*Polygonum lapathifolium*).
Pennsylvania persicaria (*Polygonum pennsylvanicum*).
Smartweed (*Polygonum punctatum*).
Virginia knotweed (*Polygonum virginianum*).
Hastate tearthumb (*Polygonum arifolium*).
Goosefoot (*Chenopodium* sp.).
Pigweed (*Amaranthus* sp.).
Chickweed (*Alsine media*).
Vetch (*Vicia* sp.).
Cranesbill (*Geranium* sp.).
Sorrel (*Oxalis* sp.).
Croton (*Croton* sp.).
Spurge (*Euphorbia* sp.).
Spiny sida (*Sida spinosa*).
Violet (*Viola* sp.).
Dodder (*Cuscuta* sp.).
Stickweed (*Lappula* sp.).
Gromwell (*Lithospermum arvense*).
White vervain (*Verbena urticaefolia*).
Blue vervain (*Verbena hastata*).
Rib grass (*Plantago lanceolata*).
Plantain (*Plantago* sp.).
Buttonweed (*Diodia teres*).
Prickly sow-thistle (*Sonchus asper*).
Ragweed (*Ambrosia artemisiaefolia*).
Sunflower (*Helianthus* sp.).
Sticktight (*Bidens* sp.).

COLEOPTERA.

Ground beetles (Carabidæ):
  Calosoma scrutator.
  Pasimachus sp.
  Scarites subterraneus.
  Dicaelus sp.
  Callida sp.
  Harpalus caliginosus.
  Anisodactylus rusticus.
  Anisodactylus agricola.
Click-beetles (Elateridæ):
  Melanotus sp.
Bronzy wood-borers (Buprestidæ):
  Dicerca obscura.
  Agrilus egenus.
Fireflies (Lampyridæ):
  Chauliognathus marginatus.
  Telephorus pusillus.
Lamellicorn beetles (Scarabæidæ):
  Phanaeus carnifex.
  Aphodius lividus.
  Aphodius inquinatus.
  Macrodactylus subspinosus.
  Anomala binotata luteipennis.
  Pelidnota punctata.
  Allorhina nitida.
  Euphoria fulgida.
  Euphoria inda.
Long-horned beetles (Cerambycidæ):
  Liopus adspersus.
  Hippopsis lemniscata.
Leaf-beetles (Chrysomelidæ):
  Donacia sp.
  Lema trilineata.
  Cryptocephalus calidus.
  Colaspis brunnea.
  Nodonota tristis.
  Chrysomela sp.
  Calligrapha bigsbyana.
  Zygogramma heterotheca.
  Melasoma scripta.
  Diabrotica 12-punctata.
  Odontota dorsalis.
  Coptocycla sp.
Darkling beetles (Tenebrionidæ):
  Blapstinus pratensis.
Blister beetles (Meloidæ).
Scarred snout-beetles (Otiorhynchidæ):
  Graphorhinus vadosus.
  Compsus auricephalus.
True snout-beetles (Curculionidæ):
  Sitones sp.
  Pachytychius amœnus.
  Anthonomus grandis.

COLEOPTERA—continued.

- True snout-beetles—Continued.
  - *Conotrachelus* sp.
  - *Tyloderma baridium.*
  - *Baris interstitialis.*
  - *Balaninus nasicus.*
- Billbugs (Calandridæ):
  - *Rhodobaenus 13-punctatus.*
- Billbugs—Continued.
  - *Sphenophorus cariosus.*
  - *Sphenophorus compressirostris.*
- Barkbeetles (Scolytidæ):
  - *Tomcius impressus.*

HEMIPTERA.

- Cicadas (Cicadidæ):
  - *Cicada tibicen.*
- Tree-hoppers (Membracidæ).
- Leaf-hoppers (Tettigonidæ).
- Jumping plant-lice (Psyllidæ).
- Scale insects (Coccidæ):
  - *Eulecanium cerasifex.*
  - *Eulecanium robiniarum* (?).
- Scale insects—Continued.
  - *Toumeyella* sp.
- Stink-bugs (Pentatomidæ):
  - *Euschistus* sp.
  - *Nezara hilaris.*
- Lygæidæ.
- Assassin bugs (Reduviidæ).

ORTHOPTERA.

- Short-horned grasshoppers (Acridiidæ):
  - *Melanoplus atlanis.*
  - *Tettix* sp.
- Long-horned grasshoppers (Locustidæ).
- Crickets (Gryllidæ).

LEPIDOPTERA.

- Hawk-moths (Sphingidæ):
  - *Deilephila lineata.*
  - *Sphinx kalmiæ.*
- Owlet-moths (Noctuidæ):
  - *Mamestra picta.*
  - *Prodenia ornithogalli.*
  - *Alabama argillacea.*
- Owlet moths—Continued.
  - *Heliothis obsoleta.*
- Spanworms (Geometridæ):
  - *Nadata gibbosa.*
- Leaf-rollers (Tortricidæ):
  - *Carpocapsa pomonella.*

HYMENOPTERA.

- Rough-headed ants (Myrmicidæ):
  - *Pogonomyrmex* sp.
- Smooth-headed ants (Formicidæ):
  - *Lasius* sp.
- Sawflies (Tenthredinidæ).

OTHER INSECTS.

- Dragon fly (Odonata).
- *Mantispa brunnea* (Neuroptera).
- Two-winged fly (Diptera).
- Mayfly (Ephemerida).

OTHER INVERTEBRATES.

- Spiders (Araneida).
- Centipedes (Chilopoda).
- Snails and slugs (Gastropoda).
- Bivalves (Pelecypoda).

GRAY GROSBEAK.

(*Pyrrhuloxia sinuata.* Plate I, Frontispiece.)

APPEARANCE, DISTRIBUTION, AND HABITS.

This grosbeak, which so far has received no distinctive popular name, may be known as the gray grosbeak or parrot-bill. It is almost the same size as the cardinal, closely resembles that species in song and general demeanor, and has similar nesting habits. Moreover, it frequents the same kind of country and is resident wherever found. In appearance, however, it is quite dissimilar.

In strong contrast to the glowing hue of the cardinal, the general color of both sexes of the parrot-bill is light gray. The wings, tail, and long crest are suffused with dark red and the wings are lined with rose. This color also surrounds the beak of the male and extends over throat and breast in an irregular patch. The beak is yellowish and is very curiously modified, being short, thick, strongly curved, and apparently of great power.

The gray grosbeak occurs over about the lower third of Arizona and New Mexico and the lower half of Texas, not reaching, however, the extreme eastern part of the latter State. There are two subspecies, the Arizona parrot-bill (*P. sinuata*) and the Texas parrot-bill (*P. s. texana*). Their range extends south to central Mexico.

ECONOMIC RELATIONS.

Seventy-four stomachs of gray grosbeaks have been examined. All are from Texas, 59 being collected in August and 15 in September. They do not, therefore, give an adequate idea of the food habits of the species, except for that locality and season. Vegetable matter averages 71.19 percent of the contents, and animal matter 28.81 percent. Contrasting the latter amount with 36.54 percent of animal food obtained during a corresponding period by the cardinal, which is highly vegetarian, it appears exceedingly low. It is accounted for, however, by the extraordinary preference of the parrot-bill for a single item of its vegetable diet, namely, the seeds of grasses.

VEGETABLE FOOD.

Another remarkable feature of the vegetable diet is the scarcity of fruit. Only a few pokeberries were eaten, not enough in fact to be allotted a percentage valuation. Cardinals, however, collected in the same locality at the same time consumed almost 12 percent of fruit in August and nearly 30 percent in September. It appears, therefore, that the gray grosbeak is distinguished from its nearest relative by a remarkable indifference for fruit.

WEEDS.

Grass seeds constitute an average of 53.09 percent of the total food of the birds examined, or more than five-sevenths of the vegetable food alone. Most important among them are foxtail (*Chætocholoa*, fig. 17) and bur grass (*Cenchrus*, Plate II, fig. 10), which together amount to 43.59 percent of all the bird's food. Since these grasses are among the most pernicious weeds, the parrot-bill is more than welcome to all of their seeds it desires.

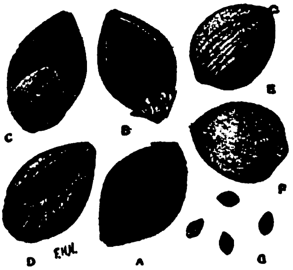

FIG. 17.—Seeds of yellow foxtail (*Chætochloa glauca*). (From Hillman, Nevada Experiment Station.)

The seeds of other grasses also are important, furnishing 9.51 percent of the bird's subsistence. Among them are seeds of witch and crab grasses, most species of which are weeds. Yard or wire grass (*Eleusine indica*) also is eaten. Seeds of a spurge (*Croton* sp.) contribute 9.81 percent to this grosbeak's fare, and other weeds, including bindweed (fig. 21), lambs' quarters, tumbleweed (fig. 18), sunflower, carpet weed, nightshade, vervain (fig. 3), mallow, etc., compose 6.13 percent.

Thus the gray grosbeak is a great consumer of weed seeds, and it is remarkable that seeds form practically seven-tenths of the food in August and September, when insects are superabundant. The bird's habit of feeding upon weeds is undoubtedly beneficial, especially because it eats so many seeds of foxtail and bur grass, pests with which every farmer in the South has to contend.

GRAIN.

The only grain found in stomachs of this species is sorghum. Six birds had eaten it in quantity sufficient to make an average of 2.03 percent of the total food. Ignoring even the fact that sorghum is usually grown for fodder, not for grain, the amount consumed is so small that there need be no fear of damage by this shy and uncommon bird.

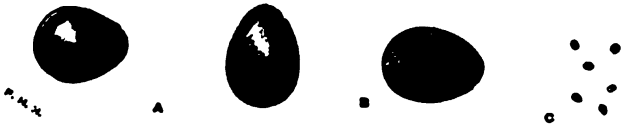

FIG. 18.—Seeds of rough tumbleweed (*Amaranthus retroflexus*). (From Hillman, Nevada Experiment Station.)

ANIMAL FOOD.

While the parrot-bill consumes a smaller proportion of animal matter than other grosbeaks, it selects about the same things, the principal items being grasshoppers, caterpillars, and beetles.

Neither parasitic Hymenoptera nor predaceous beetles were found in the stomachs examined, a showing much to the bird's credit. Only one useful insect had been eaten, it belonging to the queer neuropteroid genus *Mantispa*, the members of which are rare. They are predaceous when adult and when young are parasitic in the egg-sacs of spiders.

The remainder of the animal food is composed of injurious species, among which are important pests. Beetles constitute 4.66 percent of the food, weevils alone being 3.42. Of greatest interest among the latter is the cotton-boll weevil (*Anthonomus grandis*, fig. 19), the most serious agricultural pest of recent years. While the gray grosbeak does not feed upon it regularly, nevertheless the habit of picking it up when occasion offers is highly commendable. Among other weevils eaten are additional species of curculionids and scarred snout-beetles, including the same silvery-green and golden species (*Compsus auricephalus*) eaten by the cardinal.

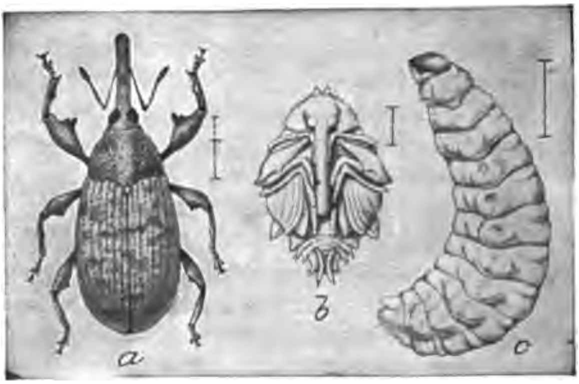

FIG. 19.—Cotton-boll weevil (*Anthonomus grandis*). (From Howard, Bureau of Entomology.)

Leaf beetles (Chrysomelidæ) probably are next in importance. The parrot-bill is sharp-eyed enough to find a species (*Chlamys plicata*) of this family that is noted for the perfection of its protective devices. This little beetle is curiously sculptured and has furrows in which all the appendages fold, and, being bronzy in color, its resemblance to the droppings of caterpillars is almost perfect. The *Chlamys* sometimes feeds upon raspberry leaves, but has never been found very injurious. Nevertheless, it is entirely vegetarian, like all the other beetles of the family, species of which, even if not at present positively injurious, are liable to become so at any time. The parrot-bill should receive nothing but praise for its destruction of leaf-beetles.

Bronzy wood-borers (Buprestidæ) and long-horned beetles (Cerambycidæ), both of which are destructive to forest and orchard trees, also were found in stomachs of this species.

Beetles, as a whole, are exceeded in amount by caterpillars, the latter constituting 10.32 percent of the diet. One of the species identified, namely, the cotton worm (*Alabama argillacea*, fig. 20), has long been known as a great pest throughout the Southern States, and in certain years has caused a decrease in the crop of a quarter of a million bales, valued at $25,000,000. Many birds devour great numbers of cotton worms, and this fact alone justifies the oft-repeated statement that "too much can hardly be said in favor of insectivorous birds in cotton fields." The gray grosbeak assumes a proper share in this valuable work, 14 of the 74 individuals examined having consumed cotton worms, which formed an average of 39.1 percent of their food. As many as 18 caterpillars were found in a single stomach. Another caterpillar enemy of the same crop, the cotton cutworm (*Prodenia ornithogalli*, fig. 9), also is freely devoured.

As beetles were less esteemed than caterpillars by the gray grosbeak, so also are the latter less liked than the Orthoptera. This group contributes 11.52 percent of the total food. Both long and short-horned locusts and their eggs are devoured, 7 or 8 grasshoppers sometimes being secured by a single bird. The only species (*Syrbula admirabilis*) identified sometimes feeds on timothy.

True bugs, comprising stink-bugs (Pentatomidæ) and their eggs, cicadas, leaf-hoppers (Jassidæ), and lantern flies (Fulgoridæ) compose about 1.5 percent of the food. All of these insects are injurious and the bird does a service by feeding upon them.

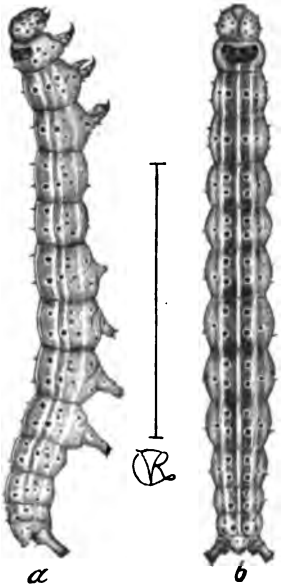

Fig. 20.—Cotton worm (*Alabama argillacea*). (From Riley, Bureau of Entomology.)

One parrot-bill was bold enough to swallow a large hornet (*Vespa* sp.). A few ants also were eaten, and these, together with spiders and snails, complete the list of animals devoured. Although this grosbeak is not conspicuously insectivorous, almost all the insects it eats are injurious.

MINERAL MATTER.

While mineral matter was absent from the majority of the stomachs examined, enough was contained in the remainder to make an average of 3.62 percent for the whole number.

SUMMARY.

The present incomplete data indicate that for a grosbeak the parrot bill is decidedly vegetarian, preferring vegetable food even in months when insects abound. More than 69 percent of its food during August and September consists of weed seeds, the small amount of grain taken bringing the total amount of vegetable food up to 71.19 percent. More than half of the total subsistence consists of grass seeds alone.

The 28.81 percent of animal food is made up almost exclusively of harmful species, among which are the most important pests of the cotton plant, namely, the cotton worm and the cotton boll weevil.

Although the data on hand are insufficient to determine the exact economic status of the bird, it may be stated with confidence that the gray grosbeak is almost entirely beneficial.

LIST OF SEEDS AND INVERTEBRATES EATEN BY THE GRAY GROSBEAK.

GRAIN.

Kafir corn (*Sorghum vulgare durra*).

WEEDS.

- Joint grass (*Paspalum* sp.).
- Crab grass (*Syntherisma* sp.).
- Yellow foxtail (*Chætochloa glauca*).
- Bur grass (*Cenchrus tribuloides*).
- Wire grass (*Eleusine indica*).
- Bindweed (*Polygonum* sp.).
- Goosefoot (*Chenopodium* sp.).
- Rough pigweed (*Amaranthus retroflexus*).
- Pokeweed (*Phytolacca decandra*).
- Carpetweed (*Mollugo verticillata*).
- Sorrel (*Oxalis* sp.).
- Spurge (*Euphorbia* sp.).
- Croton (*Croton* sp.).
- Mallow (*Malva* sp.).
- *Sida* sp.
- Vervain (*Verbena* sp.).
- Nightshade (*Solanum* sp.).
- Sunflower (*Helianthus* sp.).

COLEOPTERA.

- Bronzy wood-borers (Buprestidæ).
- Long-horned beetles (Cerambycidæ):
  - *Liopus crassulus.*
  - *Hippopsis lemniscata.*
- Leaf-beetles (Chrysomelidæ):
  - *Chlamys plicata.*
- Scarred snout-beetles (Otiorhynchidæ):
  - *Compsus auricephalus.*
- True snout-beetles (Curculionidæ):
  - *Anthonomus grandis.*
  - *Acalles* sp.

HEMIPTERA.

- Cicadas (Cicadidæ):
  - *Cicada* sp.
- Leaf-hoppers (Jassidæ).
- Lantern flies (Fulgoridæ).

ORTHOPTERA.

- Short-horned grasshoppers (Acrididæ):
  - *Syrbula admirabilis.*
- Long-horned grasshoppers (Locustidæ).

LEPIDOPTERA.

- Owlet-moths (Noctuidæ):
  - *Prodenia ornithogalli.*
  - *Alabama argillacea.*

HYMENOPTERA.

Hornets (Vespidæ):
  Vespa sp.

Smooth-headed ants (Formicidæ).

NEUROPTERA.

Mantispidæ: *Mantispa* sp.

OTHER INVERTEBRATES.

Spiders (Araneida).

Snails (Gastropoda).

ROSE-BREASTED GROSBEAK.

(*Zamelodia ludoviciana*, Plate III.)

APPEARANCE, DISTRIBUTION, AND HABITS.

The rose-breasted grosbeak, one of the loveliest and most valuable of our North American birds, is easily recognized by its characteristic coloring and big bill. The male is gayly clad in rose, white, and black, the brightest tint partly covering the breast and lining the wings. The female, while soberly clothed in buffy, grayish, and brown, can not be mistaken, once the appearance of the species is familiar, the plump form and thick bill sufficiently distinguishing her.

The song of the male rosebreast is as charming as his appearance is striking, its notes being among the sweetest and most inspiring of the avian chorus. The bird seems never to tire of his music and may be heard during the hottest days and even at night. However, he is also a paragon of domesticity, taking turn with the female in incubating the eggs and later doing yeoman service in feeding the young.

The bulky and loosely-fashioned nest is built in June, and 3 or 4 eggs are laid. The nests are very often placed in orchard trees; indeed, where conditions permit, they are almost invariably in the vicinity of cultivated lands.

The birds are fairly common, especially in the northern part of their range, but they are not evenly distributed. For instance, in one locality, for no obvious reasons, grosbeaks are absent, while in another near by several pairs may live. In Wisconsin 7 nests have been found in a space of not over 5 acres, and on the brushy banks of a little stream in New Jersey 11 pairs nested within a quarter of a mile. If these figures held for any considerable area, they would indicate that the bird was very abundant, and indeed it would appear that in most accounts the number of rose-breasted grosbeaks has been underestimated, unless we are to assume that of late years the bird has increased in numbers greatly. In parts of New England during the last twenty years the bird is known to have increased. and where once rare it is now common. In western Pennsylvania rosebreasts are said to be as common as song sparrows, and E. A. Preble, of the Biological Survey, found them in migration one of the commonest birds along the Athabaska River, near the northern limit of their distribution.

The rosebreast ranges farther north than any other of the group of grosbeaks here treated. Breeding from the latitude of St. Louis and northeastern Kansas and in the Alleghenies from southern Tennessee, it occurs as far north as Newfoundland and Quebec in the east and in the west extends through the Dakotas and lower Saskatchewan to Peace River Landing, Alberta, and the vicinity of Fort Smith, Mackenzie—the latter locality only 6° from the Arctic Circle. In winter the species is found from southern Mexico to below the Equator in Ecuador.

ECONOMIC RELATIONS.

Much interest attaches to the present species because of its well-known fondness for the Colorado potato beetle. More than 35 printed articles of greater or less length have been devoted to the bird because of this habit, and brief reports upon it appear in four previous publications of the Biological Survey.[a]

One hundred and seventy-six stomachs of the rosebreasted grosbeak are available for present examination, and these were obtained in the seven months from April to November (excepting October), from 17 States and the District of Columbia, besides Nova Scotia, Ontario, and Northwest Territory.

A detailed inventory of the contents of these stomachs having been made and the results tabulated, it was found that the bird consumes an average of 52 percent of animal matter and 48 percent of vegetable per month during its stay in the summer home. The maximum amount (74.25 percent) of animal food is taken in June, the nesting month. Remarkable features of the food habits are the apparent disinclination for grasshoppers and the strong preference for wild fruits.

VEGETABLE FOOD.

The vegetable part of the diet is composed of the following elements: Weed seed, 15.74 percent; grain, 5.09 percent; garden peas, 1.37 percent; wild fruit, 19.3 percent, and other vegetable matter, including a small quantity of cultivated fruit, besides buds, flowers of trees, etc., 6.5 percent.

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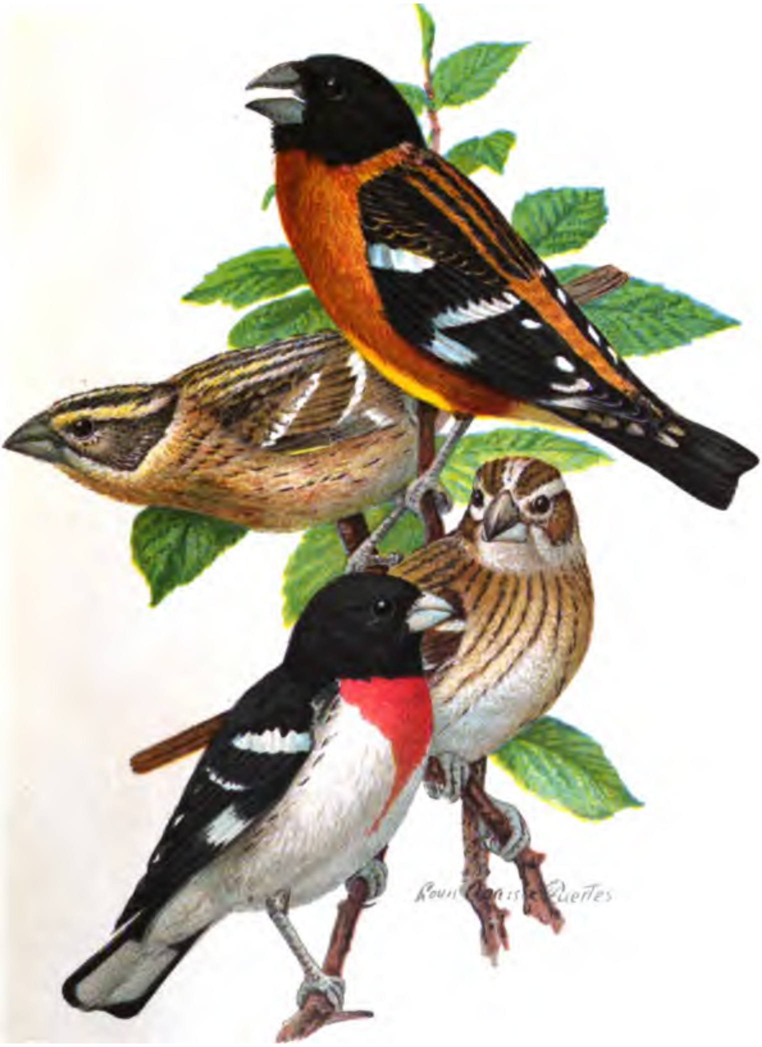
[a] Barrows, W. B., Rep. Commr. Agr. (1888), 1889, pp. 535–536; Merriam, C. Hart, Rep. Commr. Agr., 1889, p. 369; Beal, F. E. L., Farmers' Bull. 54, 1897, pp. 28–30; Beal, F. E L., Farmers' Bull. 54, rev. ed., 1904, pp. 34–35.



BLACK-HEADED AND ROSE-BREASTED GROSBEAKS

[Upper figures, black-headed grosbeaks, male and female; lower figures, rose-breasted grosbeaks, female and male.]

The items obtained from cultivated crops, being of chief interest, will be considered first. While it is needless to state that most of the testimony regarding the value of this bird is favorable, yet complaints of injury from it have been made which are verified by stomach examinations. The crop most frequently attacked by rose-breasted grosbeaks is the common garden pea.

PEAS.

Ten accounts from correspondence and published writings go to show that this grosbeak sometimes feeds upon peas. Six of them refer to damage in Iowa, two in Illinois, one in Massachusetts, and one general. Three persons regard the bird as very destructive; three, while stating that injury is committed, are less severe in their strictures; while the remaining four, admitting the consumption of a few peas, consider the bird's services in preying upon injurious insects ample compensation for the loss sustained.

The attacks of this bird upon peas were observed as early as 1839, W. B. O. Peabody[a] writing as follows:

> At the latter part of the summer, our gardens are frequented by the young in great numbers, and bitter complaints are made, with or without reason, of their depredations on the peas.

Among more recent charges of injury, that of H. J. Giddings, of Sabula, Iowa, may be cited, both because the amount of damage is extreme, and further because the observations are supported in part by stomach examination. Mr. Giddings says:

> During the last summer [1892] rosebreasted grosbeaks were unusually numerous here. * * * The last two weeks in June and the first week in July (after the young had left the nest) they became very destructive, eating all kinds of fruit and entirely destroying a small patch of green peas in my garden. (Nov. 18, 1892.)

Six grosbeak stomachs were sent in from this and other gardens where the birds had access to peas, but examination disclosed peas in only two of them, constituting in one case 10 percent of the stomach contents and in the other 80 percent. Peas were found in one other stomach also, of the 176 examined, this having been collected in Minnesota in July. It held 4 peas, which were 80 percent of the contents. Were there no other evidence, the above is sufficient to show that the rosebreast has a taste for green peas which is sometimes gratified at the expense of the gardener.

Some observers believe, however, that the bird makes full reparation for damage done. E. M. Hancock, of Waukon, Iowa, states:

> The rosebreasted grosbeak has more than made amends for its pea stealing by its determined warfare upon the Colorado potato beetle, helping very materially to keep down this pest. (April, 1886.)

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[a] Birds of Massachusetts, 1839, p. 329.

Henry Nehrling[a] writes:

> It is said to eat green peas, and for this reason it is often killed, though the damage done in this way does not compare with the many benefits it bestows.

The question is, Do stomach examinations support this view? Years ago Prof. F. E. L. Beal observed the rosebreast in the act of eating peas and found the pods cut open and the peas gone; the contents of a stomach were examined, and two or three peas, several potato beetles, and a tomato worm were found; whence it is evident that this particular grosbeak, at least, was paying well for its peas.

In this connection the record of 6 birds from Iowa gardens is of interest. Fifteen percent of their food was peas, and to that extent, of course, they were detrimental; but as an offset more than 17 percent consisted of bronzy wood-borers and 12.5 percent of weevils, including the injurious pine bark-weevil and 2 nut weevils. While these insects are very injurious to timber, it may be claimed that they are not of direct consequence to the gardener. But insects especially injurious to garden crops also were consumed, 14.8 percent of the food consisting of white grubs, which are enemies of strawberries, and a flower beetle, which injures young corn and many fruits, besides the notorious Colorado potato beetle. Caterpillars and ants also were preyed upon by these 6 birds, and scale insects (*Eulecanium* sp.), the very worst pest of fruit trees, formed 4.5 percent of their food. The gardener is vitally concerned in reducing the numbers of these insects, and it is evident that the 15 percent of peas consumed is paid for many times over by the destruction of more than three times that amount of garden and forest enemies. Moreover, to determine the true significance of the damage done, not only the birds which had eaten peas, but the species collectively must be considered. The present investigation shows that 3 birds out of 176 had stolen peas, while scores had literally feasted upon the worst enemies of agriculture. Peas constitute 1.36 percent of the total food of the grosbeaks examined, while noxious insects certainly compose thirty times as much. Viewed in the light of these facts, the loss sustained would be nothing compared to the benefits received were it not for the fact that the birds' depredations are often local in character, as in the case cited above, one cultivator, perhaps, furnishing the supply of peas for all the grosbeaks in the neighborhood.

However, even under such circumstances a remedy is available without the necessity of sacrificing the birds. Wire guards or bird netting afford protection, and in the case cited above Professor Beal at once stopped the grosbeaks' visits to his pea patch by means of an old coat on a pole.

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[a] Our Native Birds of Song and Beauty, II, 1896, p. 206.

GRAIN.

Grain composes 5.09 percent of the food of the 176 rose-breasted grosbeaks examined, the cereals selected being corn, wheat, and oats. The bird has been accused of injuring each of these products, and stomach examinations lend support to the complaints.

Corn.—Part of the damage to corn is of an unusual nature. H. S. Giddings, of Sabula, Iowa, writing about the same grosbeaks mentioned above as injurious to peas, says:

> From the time they arrived until their departure they fed continuously on corn from a crib on my place. * * * Sometimes as many as 10 or 12 would be in the crib at once.

The stomachs of 3 grosbeaks shot at this time contained corn, the grain constituting in each case about half the contents. Notwithstanding these facts, it is very doubtful if any considerable damage is ever committed in the manner described, if for no other reason than that the opportunity is seldom presented. Moreover, such depredations are easily prevented by simple and inexpensive means, such as lining the crib with wire netting and closing the doors when not in use. These precautions will not only keep out wild birds, but also rats, mice, and chickens, which animals undoubtedly destroy vastly more stored grain than all native birds together.

A small quantity of the corn eaten by the rose-breasted grosbeak may be pilfered from the growing crop, one bird taken in Pennsylvania in July having eaten enough corn to form 8 percent of its stomach contents, and one from Illinois in September consumed 50 percent. There is no way of determining positively whether this grain was crop corn or waste; but if only 2 grosbeaks out of 176 take corn from the ear, there is no cause for alarm. The corn obtained in May by 2 other rosebreasts from Illinois and Minnesota may have been either seed or waste.

Oats.—Seed oats may sometimes be devoured by grosbeaks. E. A. Mearns says:[a]

> Where fields newly sown with the cereal grains are convenient to its woodland retreats, it * * * will collect in large flocks, and resort there continually, as long as there is a grain of seed to be had.

As this statement refers to a locality in New York where the rosebreast occurs only from May to September, the crop in question must be oats.

This grain was eaten by 5 of the birds examined, 4 of which may have obtained it from newly sown fields, but even this trifling injury to the crop may be prevented and other advantages secured by drilling. The fifth grosbeak, which was collected in Illinois in July, probably obtained the oats it devoured from standing grain.

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[a] Bull. Essex Inst., 12, 1880, p. 21.

Wheat.—A certain quantity of wheat also may be taken from the heads, but no complaints of such damage have been received, the only observation at hand which bears upon the point being that of Audubon. Referring to a brood of young rose-breasted grosbeaks in the vicinity of Cincinnati, he says:[a] "The parents fed them on the soft grains of wheat which they procured in a neighboring field." Four grosbeaks out of the 176 examined had fed upon wheat. That obtained by 1 collected in Connecticut in May is obviously waste, but 3 birds, which had eaten wheat during July and August in Iowa and Illinois, may have attacked standing grain. These 4 birds obtained about 3 kernels of wheat each, which is an average of less than a fourteenth of a kernel apiece for the 176 grosbeaks examined. Now, if the proportion of grosbeaks eating wheat, 4 to 176, or thereabouts, holds true for this species at large, and the birds do not exceed the moderate average of 3 kernels each, it would require the united efforts of the grain eaters among some 300,000 grosbeaks to consume a quart (21,000 kernels) of average wheat. It is evident, therefore, that the rosebreast's wheat-eating habits can not be termed injurious.

To sum up the rosebreast's relation to grain crops, as shown by the present investigation, 15 birds out of a total of 176 fed upon grain, including oats, wheat, and corn. Wheat and corn eaten by 4 of these very probably was waste, while 3 birds had taken corn from a crib, and 4 had eaten oats which may have come from newly sown fields. In both cases the injury was easily preventable. Six grosbeaks, consuming one or the other of the grains mentioned, may have pilfered standing crops. This latter injury to grain constitutes the only real case against the bird, and involves only 1.17 percent of the total food of the birds examined. If this ratio holds true for the entire species, the damage is of no special consequence. This view is further strengthened by the fact that no complaints have been made of injury to standing grain, the only stage in which it is subject to attack under the best methods of culture.

BUDS.

All grosbeaks are usually thought to feed much on buds, and none of the species are believed to be more fond of them than the rosebreast. Most writers have commented on this habit of the rosebreast, and it is referred to also by many correspondents. However, buds were found in but 2 of the stomachs examined, while flowers of trees were found in 4, and it is quite possible that more of the records of field observers relate to flowers than to buds. Among trees whose buds are said to be devoured are beech, cherry, pear, wild plum, soft maple, box elder, and elm. Apparently some of these are greatly relished. G. E. Atkinson, of Ontario, says:[a]

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[a] Birds of America, III, 1841, p. 210.

> They cut off the buds [of beech] close to the twig, eat the soft pip, and drop the shells. On May 11, I * * * saw three rose-breasted grosbeaks feeding, * * * occasionally darting out at a passing insect. I managed to secure one and its stomach was packed with these buds.

The practical significance of the rosebreast's budding has been the subject of widely varying opinions. Seventeen statements concerning the subject are at hand, which, briefly put, are as follows: One author holds the grosbeak injurious; one thinks it may possibly be so; two perceive very little damage; one considers any detriment in this way fully recompensed by the bird's utility in other directions; ten assert that no harm whatever is done, and two declare that budding is beneficial. It will be of interest to cite in full some of these diverse opinions. E. A. Mearns writes:[b]

> Soon after its arrival, the rose-breasted grosbeak appears about our houses, and, possibly, does some damage to the fruit crops by eating the blossoms in the orchards; it is especially fond of those of the cherry, and the rapidity with which it dispatches them is quite marvelous.

H. D. Minot says:[c]

> He * * * eats buds, often committing depredations on our fruit trees; and he must be considered as injurious to agriculture. He frequently plucks blossoms, and, dexterously cutting off the petals, etc., lets them fall, while he retains the ovary which contains the seeds.

Commenting upon the latter author's statement, William Brewster observes:[d]

> There are no good reasons for assuming that this injures the trees or even their crops of fruit. On the contrary, both are probably benefited by the process, which is, in effect, a sort of fruit pruning, seldom if ever more severe than that practiced by the thrifty horticulturists.

It will have been noted that the above quotations refer to flowers, which, as previously stated, seem to be eaten much more commonly than leaf buds. Dr. B. H. Warren found flowers of hickory in 11 stomachs, those of beech in 26, maple in 3, and other blossoms in 23 stomachs collected during May in Pennsylvania. Dr. A. K. Fisher has observed rosebreasts feeding on the flowers of elm and walnut, and during the present investigation flowers of oaks were found in 4 stomachs, the blossoms in two of them being of the post oak (*Quercus minor*). No appreciable damage ensues from the bird's habit of feeding on the flowers of forest trees, since the fruits of these trees are of little economic value. Moreover, it is noticeable that the fruit-producing or pistillate flowers are not the ones preferred, but the sterile staminate ones. These are produced in countless millions, and wither and fall away after a short season. All of the plants named above, whose seeds are even occasionally utilized by man, such as the hickories, walnuts, beech, and oaks, have the staminate and pistillate flowers separate, while no use is made of the seeds of the maple and elm, which have both sexes present in a single flower.

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[a] Trans. Canad. Inst., III (1890–91), 1892, p. 40.

[b] Bright Feathers of North American Birds of Beauty, F. R. Rathbun, 1881, pp. 31–32.

[c] Land Birds and Game Birds of New England, 2d ed., 1895, p. 241.

[d] Loc. cit.

Buds were found in but 2 stomachs, those in one being identified as poplar, and remains of tender young shoots of some woody plant were eaten by another grosbeak. These results indicate a much slighter preference for buds than the bird is usually credited with. But even admitting that the bird relishes buds, it is difficult to conceive how forest and shade trees, numerous as they are, can possibly be injured, since the rosebreast never gathers in large flocks during the budding season. With fruit trees the case is different, for an isolated tree in a home garden may receive the attentions of several birds at the same time. But even then the chance of injury is slight, and in the majority of cases the tree, as stated above, receives no more than a beneficial pruning.

CULTIVATED FRUIT.

The rosebreast is said to feed occasionally on cultivated fruits, but no complaints of serious injury by the bird have been received. Most observers state that they lose but little fruit by grosbeaks, and this is considered only partial payment for services rendered. One correspondent, after mentioning the fact that the birds eat the potato beetle, says:

> They also feed on my berries. Still I plant enough for all, and put up with the loss for the sake of their good qualities.

The rosebreast is reported to attack cherries, currants, and other berries. During the examination of stomachs, however, cultivated fruit was found to have been eaten by only 1 grosbeak. This bird and a companion were collected in a cherry tree in Massachusetts, where they were suspected of pilfering the fruit. One had eaten perhaps a single mouthful of cherry, which constituted 18 percent of its stomach contents, and had eaten also some weevils, stink bugs, and a potato beetle, all highly injurious insects. Several other grosbeaks of the present collection were killed because they were thought to be eating fruit, but their stomachs yielded no trace of it.

WILD FRUIT.

While cultivated fruit is a negligible item of the rosebreasted grosbeak's bill of fare, wild fruit, on the contrary, is the most important single article, constituting 19.3 percent, or almost a fifth of the total food. Many different kinds of fruit are eaten, among which elderberries are probably of most importance. Both the common sweet elder (*Sambucus canadensis*) and the red-berried elder (*S. pubens*) were identified. Nineteen birds had eaten these fruits, which often composed from 60 to 90 percent of the stomach contents. In the gizzard of 1 grosbeak were found fully 200 seeds, which means that no less than 40 to 50 berries were taken at one meal. Blackberries and raspberries rank next in preference, 17 birds having eaten them, and they sometimes constitute 80 percent of the food of individual birds.

Mulberries also are relished, the rosebreast often being observed feeding on the wild red mulberry (*Morus rubra*). June berries (*Amelanchier canadensis*, Plate II, fig. 3) were eaten by 3 of the grosbeaks examined, 80 seeds being discovered in 1 stomach. Eight or more of these rather large fruits must therefore have been taken by this bird. Among other wild fruits eaten by the birds examined are wild red and black cherries (Plate II, fig. 1), choke cherry, rough-leaved dogwood (Plate II, fig. 6), wintergreen, checkerberry, red haw, strawberry, supple-jack, and pokeberry (Plate II, fig. 4). In addition to these, authors and correspondents add flowering dogwood (Plate II, fig. 5), juniper, and sour gum.

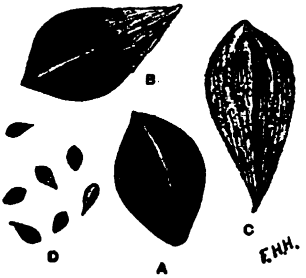

FIG. 21.—Seeds of black bindweed (*Polygonum convolvulus*). (From Hillman, Nevada Experiment Station.)

WEEDS.

Although this grosbeak is not particularly fond of the seeds of weeds, it takes part in the warfare which birds wage against these misplaced plants, and attacks some very troublesome species. Fifteen and three-fourths percent of the bird's food is composed of weed seed, and a greater proportion is consumed in August and September than in other months. The seeds of smartweed and bindweed (fig. 21), species unfavorably known both in country and town, were selected by the greater number of rosebreasts. Those of tumbleweed or amaranth (fig. 18) are next in favor, and when eaten at all almost invariably compose the major part of the stomach contents. These weeds are obnoxious almost everywhere, and their bad qualities are universally acknowledged. Seeds of foxtail (figs. 17 and 37), highly valued in the dietary of many birds, were fed upon by but 2 rose-breasted grosbeaks, and other grass seeds—a small wild oat in 2 cases—were eaten by 4 of the birds examined. Nightshade and sedge seeds were each selected by the same number of birds. The akenes of both common (fig. 6) and giant ragweed were sampled, and the seeds of vervain (fig. 3) and dock are occasionally devoured. Milkweed and sunflower are added to this list by other writers.

MISCELLANEOUS VEGETABLE FOOD.

The rosebreast feeds upon some vegetable matter which does not fall into any of the previously discussed categories. Seeds of the touch-me-not and blood-root, plants widely known for their flowers, are examples. Each was eaten by 1 individual, and 1 fed upon red-bud seeds also, which constituted 80 per cent of its stomach contents. The spiny, globe-like fruits of the sweet gum (*Liquidambar styraciflua*) are bitten into occasionally, but the remains found in the stomach so resemble another but unknown substance that it was possible to identify them certainly in only one instance, and then by means of the very characteristic fertile seeds. The pendent sycamore balls are sometimes rifled of their seed, as also are the aments of alder and birch.

Among the objects most puzzling to classify economically are the curious excrescences of plants, known as galls. These, as is well known, are nurseries for insects, within which the larvæ develop. They are eaten by many birds, extensively by some, and in an instance cited by Dr. A. D. Hopkins,[a] turkeys, chickens, and even hogs and cattle fattened on an abundant gall of the black oak, known in Missouri and Arkansas as " oak wheat " or " wheat mast." An analysis accompanies this note which leaves no doubt that the nourishing elements of galls are of vegetable, not animal, origin. Although this may not be true of all galls, such as certain thin-walled kinds made by plant lice in which at the proper stage the bulk of the imprisoned insects exceeds that of the shell, yet generally, no doubt, it is safe to classify galls as vegetable food. This has been done in the case of those eaten by grosbeaks. Nine rosebreasts had eaten galls, but in only one instance did they compose as much as half the food. The galls eaten appeared to be similar to the spherical species common on oaks.

ANIMAL FOOD.

Animal food, consisting almost exclusively of insects, composes 52 percent of the food of the rose-breasted grosbeak. Nearly 36 percent is beetles, 3.82 percent caterpillars, 6.43 percent Hymenoptera, and 2.38 percent scale insects, the remainder (about 3.33 percent) being made up from several other groups of invertebrates. While the rosebreast feeds upon a large number of formidable insect pests, it devours some beneficial species also. The latter are accorded prior consideration.

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[a] Proc. Ent. Soc. Wash., V, 1903, pp. 151-152.

As just noted, almost 6.5 percent of the total food is Hymenoptera, and as this group contains some of the most useful of all insects, it must be ascertained how many, if any, of these forms fall a prey to the bird. The beneficial Hymenoptera are the small parasitic species, the eggs of which are deposited in the bodies of caterpillars and in the eggs of many insects, to develop there and later destroy their hosts, and the larger wasps, which store up caterpillars and other creatures as food for their young. Very few parasitic species were found in the stomachs, the larger Hymenoptera apparently being preferred. In many cases a single wasp composed from 40 to 90 percent of the stomach contents of individual grosbeaks. It is possible that among these are some of the highly beneficial solitary wasps, but the probabilities are that most of them belong to the more abundant, gregarious species, which although often beneficial would lose little by the destruction of few of their number.

Fifty-four of the 176 grosbeaks examined were found to have eaten Hymenoptera of some sort, which shows that the bird has a decided liking for these insects; but, as just mentioned, few beneficial species are eaten, while a number of injurious ones are devoured. One grosbeak secured a cuckoo fly (*Chrysis* sp.), which is a parasite of the useful solitary wasps. Three fed upon sawfly larvæ, which have habits like caterpillars, and are injurious to roses, currants, pear, willow, and other plants. One bird when collected had 10 sawfly larvæ in its beak, which it was probably gathering for its young; while in the stomach of another grosbeak were 24 of these larvæ, which constituted 60 percent of the contents. The few ants taken are injurious, especially those of the genus *Camponotus*, which sometimes devour the wood of living trees, hollowing them out to mere shells. Two rosebreasts ate little mining bees (*Andrena*), one consuming 26 of these and nothing else. They have no special economic significance except as carriers of pollen.

Passing now to beetles, this grosbeak was found to prey upon members of three useful families, the ground-beetles (Carabidæ), ladybirds (Coccinellidæ), and fireflies (Lampyridæ). Seven birds ate predaceous ground-beetles, but since they compose only a little more than 0.5 percent of the food from May to September, little harm is done. One of the 7 grosbeaks captured a large shining black ground-beetle (*Pasimachus depressus*), which is about an inch in length and is one of the most powerful insects of the family.

Three birds ate coccinellid beetles, one securing a twice-stabbed ladybird (*Chilocorus bivulnerus*), a noted enemy of scale insects. If many such beetles were eaten, damage would be done, but as they compose less than 0.2 percent of the total food, it is evident that only occasionally one is snapped up. Moreover, the grosbeak compensates for any injury done in this way by feeding upon the prey of these beetles—the scale insects.

Fireflies, which are predaceous both in the larval and adult stage, are constantly fed upon by grosbeaks. These insects are supposed to be excellent examples of protected species, having the power of secreting nauseous juices, while the " fire " is supposed to act as a warning signal and certify the bearer's identity to its enemies. It is said that some birds refuse them. However, since 28 rose-breasted grosbeaks fed upon them and 6 to 12 of the beetles were found in single stomachs, they must be relished by this species at least. Fireflies prey upon many important agricultural pests; hence the destruction of any considerable number of them is a loss; and while but 2.71 percent of the grosbeak's food consists of these useful beetles, the bird is chargeable with a distinctively injurious habit.

Thus far only a fourth of the rosebreast's animal food has been discussed. Less than half this amount, or only about a tenth of the total animal matter, is made up of beneficial insects whose destruction is a loss to man. The remaining nine-tenths consists in part of insects of neutral import, but mostly of positively injurious species.

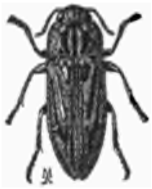

FIG. 22. — Pine buprestid (*Chalcophora virginiensis*). (Marx del. Bureau of Entomology.

Included in the latter category are the bronzy woodborers (Buprestidæ), among the most serious pests to fruit and forest trees. The larvæ, known as flatheaded borers, do the mischief, often killing trees by completely girdling them just under the outer bark. The adults are incased in a glittering coat of hardest mail, and although they expose themselves on flowers and leaves or on the limbs of trees, they are not fed upon to a marked degree by most birds. The rose-breasted grosbeak, however, seems to relish them, 3.02 percent of its food being composed of these well-protected beetles. The larger species are sometimes captured, one grosbeak having obtained the bulky buprestid *Chalcophora virginiensis* (fig. 22), which is very destructive to pines. This species is an inch in length and as firm and hard as a nut. Smaller species of another genus (*Dicerca*, including *D. obscura*), which feed on hickory and other deciduous trees, also are devoured. Many others not identified were eaten by the 26 grosbeaks which secured buprestids, and the rosebreast must be characterized as one of the important enemies of these beetles.

Resembling the buprestids in compact build and equaling them in evil qualities are the click-beetles (Elateridæ), the larvæ of which are commonly known as wireworms. Their attacks on meadow-grass, grains, and strawberries are of annual occurrence, and result in much damage. Twenty-three grosbeaks, or about one-seventh of the number examined, devoured click-beetles, thus benefiting the farmer considerably.

Not so many of the birds fed upon long-horned borers, but the resulting benefits are less valuable only in degree, as the beetles of this family are often disastrous pests. They are frequently large and strikingly colored, and one of the handsomest, as well as the most injurious kinds, the painted hickory borer (*Cyllene pictus*) is eaten by the rosebreast. This insect is known as the commonest and most destructive pest of the hickory. Another borer also (*Phymatodes varius*), which lives in dead wood, and which is sometimes injurious to the tanbark industry in the South, is devoured.

The rosebreast shows particular fondness for large beetles, a taste readily gratified among the lamellicorn or scarabæid beetles. Among these larger species, beetles of the genus *Dichelonycha*, which feed upon flowers and sometimes are destructive to cultivated plants, were eaten by 9 rosebreasts. Six ate cetoniids (*Euphoria fulgida*, et al.), which are especially adapted for feeding on flowers, and which also at times turn their attention to fruit and the tassels, silk, and young grains of corn. The beautiful and bulky goldsmith beetle, about three-fourths of an inch long, is captured occasionally, and for this service the bird is to be commended, as sometimes the larvæ are very destructive to strawberries. A white grub or larva of a june-bug was the plump morsel obtained by another grosbeak. The ravages of this beetle in lawns and strawberry plots are well known. The bird feeds also upon another good-sized scarabæid (*Anomala binotata*), which injures grapes and other plants.

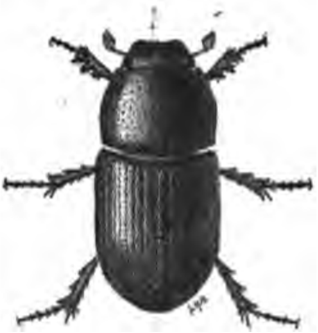

FIG. 23.—Seed corn scarabæid (*Aphodius granarius*). (From Forbes, Illinois Experiment Station.)

Among the smaller members of this family the dung beetles, which occur in large numbers, flying near the ground along country roads, are frequently captured by this grosbeak. Most of them are of neutral economic position, but one species (*Aphodius granarius*, fig. 23), burrows into sprouting corn. Having this bad habit, the farmer is indebted to the grosbeak for preying upon it.

Passing to a group of beetles, the weevils, which are an important element of the food of most birds, and which are so uniformly injurious that almost any one of them may be deemed a pest, it is gratifying to note that the rosebreast does its share toward checking them. Moreover, among the kinds it eats is one of the very worst enemies of cultivated fruit in the United States, namely, the plum curculio (*Conotrachelus nenuphar*, fig. 24). One grosbeak devoured three of these destructive weevils, which may be taken as indicating that an opportunity to feed on them is not overlooked. In this connection it is of interest to recall the other birds that are known to prey upon this pest. They are 8 in number: Great-crested flycatcher, Baltimore and orchard orioles, yellow-throated vireo, bank swallow, veery, hermit thrush, and bluebird. The grosbeak does not confine itself to the plum curculio, but evinces a taste for related species, two of which were identified. These infest the hackberry and hickory, respectively. A fourth kind was present in the stomachs, but could not be assigned a specific name. The curculios destroy a large proportion of the fruit of the trees they attack, and are capable of doing vast damage; hence the services of the birds that devour them are of great value.

Related to the curculios are the nut weevils (*Balaninus*), which attack their favorite plants in much the same way, and often ruin the crop of nut-bearing trees. Six grosbeaks ate from 1 to 3 each of these weevils, one bird capturing 2 acorn weevils (*B. nasicus*). Another curculionid (*Hylobius pales*), which feeds both in living pine trees and pine logs, is included in the grosbeak's diet, and a weevil (*Ampeloglypter sesostris*), which infests the Virginia creeper, was highly relished by an Illinois rosebreast, 11 being eaten, which constituted 74 percent of the stomach contents. Others in the same group are consumed, as many as 4 or 5 being eaten by individuals of the more than 20 birds which fed upon them.

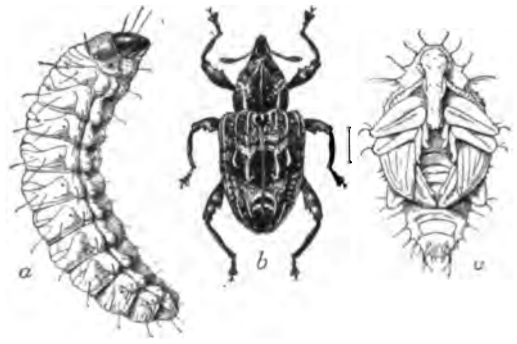

FIG. 24.—Plum curculio (*Conotrachelus nenuphar*). (From Chittenden, Bureau of Entomology.)

A second family of weevils, the scarred snout-beetles, also contributes to the fare of this grosbeak, and four of them composed 87 percent of the food of one bird; while another rosebreast, one of four which fed upon clover weevils (*Sitones*), captured 13. Billbugs (Calandridæ) are represented in the bird's diet by the conspicuously red and black colored snout-beetle (*Rhodobaenus 13-punctatus*), common on thoroughwort (*Eupatorium*). A weevil of yet another branch of the suborder is sometimes devoured, namely, the peculiar brenthid (*Eupsalis minuta*), a very slender weevil which bores into living oak. Altogether weevils constitute 3.64 per cent of the rosebreast's food, in which amount are included several great pests; hence the bird's weevil-eating propensities result in much benefit to man.

There remains for consideration the family of beetles which contributes most largely to the grosbeak's subsistence, namely, the leaf-beetles (Chrysomelidæ). This family, as an item of food of the rosebreast, is not only most important among beetles, but is only second among both animal and vegetable items. In it are included a number of pests preyed upon by the bird, such as the striped and spotted cucumber beetles, the strawberry rootworm, the plum leaf-beetle, the locust leaf-miner, and in addition that pest which figures so largely in any discussion of the economic value of the rose-breasted grosbeak, the notorious Colorado potato beetle (fig. 25).

The original home of this insect was in Mexico and the Rocky Mountains, where it fed upon the sand-bur (*Solanum rostratum*), a plant closely related to the potato. Finding a new and abundant supply of food in the cultivated potato, the beetle immediately began to multiply and to migrate eastward, spreading from 1850 to 1874 over the northern half of the eastern United States. As it encountered practically no enemies in its new home it became so abundant and inflicted so great damage that successful cultivation of potatoes seemed no longer possible. However, just as the beetle found a new food, so it in turn became new food to a number of mammals, birds, and insects, and presently the farmers learned to destroy it in large numbers with poisons. Hence it is no longer greatly dreaded, though in most sections constant vigilance must be exercised to prevent it from ruining the crop.

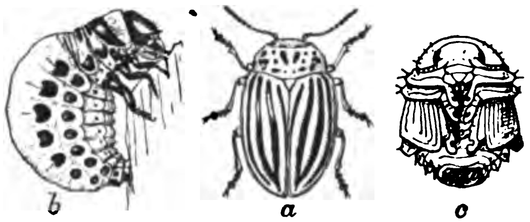

FIG. 25.—Potato beetle (*Leptinotarsa decemlineata*). (From Chittenden, Bureau of Entomology.)

Naturally during the period when the beetle was doing most damage everyone was on the lookout for means of checking its increase, and the discovery of each new natural enemy was heralded far and wide. Attracting most notice among these was the rose-breasted grosbeak, and many articles were written calling attention to the newly discovered trait of this beautiful bird. It should be noted also that several other birds, including the bobwhite, prairie chicken, sharp-tailed and ruffed grouse, red-tailed hawk, nighthawk, cuckoo, crow, English sparrow, cardinal, scarlet tanager, wood, hermit, and olive-backed thrushes, and robin, eat potato beetles occasionally.

The grosbeak's habit of feeding on the potato beetle was noted almost simultaneously in many localities, and references are at hand for the States of Missouri, Iowa, Minnesota, Wisconsin, Illinois, Michigan, and Ohio. The rosebreast actually exterminated the potato beetle in many patches it patrolled. Mr. W. F. Bundy,[a] who was among the earliest to write upon the subject, says:

> I noticed last summer that great numbers of the Colorado potato beetles were destroyed by the rosebreasted grosbeak. * * * They were so abundant in this region [Jefferson, Wis.] * * * as to hold in check the vast army of these ravagers of the potato crop.

The beetles are attacked as soon as they emerge from their winter quarters, according to Mr. J. S. Cook,[b] of northern Illinois, who says:

> I have seen them so gorge themselves with these beetles that they were scarcely able to fly. I have investigated in the spring, when the beetles first came out of the ground, and was unable to find a single one after following these birds.

Further testimony to the value of the bird is given by Prof. F. E. L. Beal,[c] who watched the grosbeaks and their young feeding upon the potato bugs in his garden at Ames, Iowa:

> When a careful inspection was made a few days later not a beetle, old or young, could be found; the birds had swept them from the field and saved the potatoes.

Comparison of the dates of the first appearance of the Colorado beetle with the earliest records when the rose-breasted grosbeak fed upon it shows that from six to ten years passed before the bird commonly began to prey upon the insect. Even after the lapse of so much time it was one of the first enemies of the beetle noted and by far the most important among birds.

The results of stomach examinations fully corroborate the testimony of field observers as to the extent to which the rosebreast feeds upon this beetle. Forty-three, or almost one-fourth of the birds examined, fed upon the potato beetle to such an extent that the insect makes up 9.05 percent of the subsistence of the entire number and nearly 35 percent of that of the individuals eating it. The significance of these figures will be better appreciated when it is considered that the potato beetle probably was not obtainable by many of the grosbeaks, and furthermore, that it is very unusual for birds to prey so extensively upon a single kind of insect, or even on the species collectively of a whole group. Such concentration of attack of a common bird upon a single species of insect, however numerous, can not but have a restraining influence on its numbers. The beetle is fed upon from May to September and both larvæ and adults are devoured, 10 to 14 being found in single stomachs. By feeding upon the larvæ the rosebreast directly benefits the potato plants, and by destroying adults the increase of the species is checked.

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[a] Am. Nat., IX, 1875, p. 375.

[b] Trans. Ill. Hort. Soc., 37 (1903), 1904, pp. 331-332.

[c] U. S. Dept. Agr., Farmers' Bul. 54, 1904, p. 35.

Although the potato beetle is the worst pest in the Chrysomelidæ, this family contains other serious enemies of crops. The rosebreast feeds upon several of them, thereby further commending itself to our esteem. Both the small striped and the spotted cucumber beetles (fig. 26), which are abundant and injurious over much of the United States, are consumed. The importance of the bird's inroads upon one of these little black and yellow species, which in the larval stage is the destructive corn root-worm, is emphasized by the fact that no direct method of combating the insect has yet been devised. Twelve grosbeaks fed upon these beetles, as many as 7 being found in a single stomach. Further evidence of the bird's strong preference for them is furnished by Mr. Ridgway, who observed a number of rosebreasts feeding exclusively on spotted cucumber beetles in a locality where the latter were very abundant.

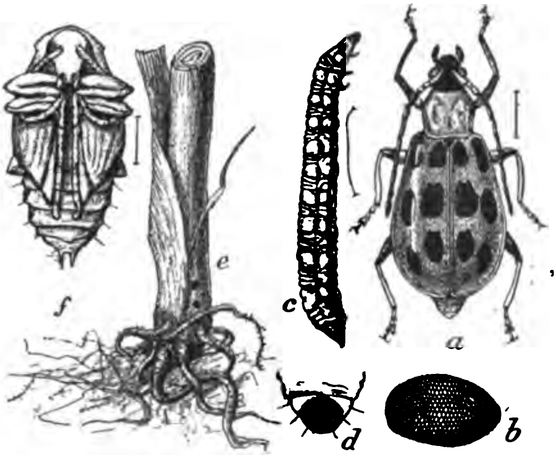

FIG. 26.—Spotted cucumber-beetle (*Diabrotica 12-punctata*). (From Riley and Chittenden, Bureau of Entomology.)

Ten of the grosbeaks examined had eaten another kind of leaf-beetle (*Melasoma lapponica*), which feeds on willows and poplars, sometimes working havoc by defoliating trees, especially in windbreaks. These beetles appear to be much relished, as from 10 to 27 were taken by individual rosebreasts, of whose food they composed from 60 to almost 100 percent. Two or three other species of Chrysomelidæ, injurious to willows, to grapes, and to garden crops, are devoured. Nine birds ate beetles of one of these species (*Calligrapha bigsbyana*), which in individual cases constituted 70 per cent of the stomach contents. The rosebreast devours also two Hispid leaf-beetles, one of which causes considerable injury. This is the locust leaf-miner (*Odontota dorsalis*), which sometimes devastates whole groups of trees, leaving them as if scorched by fire. Eight grosbeaks had eaten leaf-miners, and in one case 8 were consumed by a single bird.

The long list of beetles of this family that are preyed upon by the rosebreast is completed by the strawberry root-worm (*Typophorus* *canellus*), which at times is very destructive, the plum leaf-beetle (*Nodonota tristis*), which causes dropping of cotton bolls, a species (*Griburius equestris*) which feeds on wild roses, and another wild-flower beetle (*Cryptocephalus quadrimaculatus*).

With the Chrysomelidæ is concluded also the list of principal Coleopterous families. The grosbeak eats few others. One rose-breast devoured 5 of the decidedly malodorous burying beetles (*Silpha noveboracensis*), which feed on carrion, while another captured one hard, polished *Hister*, an insect of similar habits. Sixteen of the little orange and black *Ips fasciatus* were secured by one of the three birds which fed upon this occasional depredator of stored vegetables and grain.

It thus appears that a large number of the beetle enemies of agriculture are preyed upon by the rose-breasted grosbeak. An almost equal array of serious pests is secured from the ranks of another order, which is eaten to only one-ninth the extent that beetles are, namely, the moth and butterfly order or Lepidoptera.

This group may be discussed conveniently under the heads "larvæ" and "adults." The latter do not seem to be eaten to any great extent by birds, and only 2 rosebreasts fed upon them. Four moths were secured, but they composed less than 0.2 percent of the total food. The larvæ or caterpillars, however, are more generally relished by birds and often are eaten in large numbers. Twenty-two out of the 176 rosebreasts had eaten caterpillars, some of them securing from 6 to 14 each, which usually constituted from 50 to 85 percent of the stomach contents. They make up 3.82 percent of the entire food of all the rosebreasts examined.

It is well known that at times the depredations of lepidopterous insects, such as canker worms, tent caterpillars, gipsy moths, and many others, are very serious, threatening ruin to orchards and even large forests, and thus becoming of State, if not National, importance. The difficulties encountered in combating such pests render the aid of natural enemies most valuable. It should be widely known that the rose-breasted grosbeak is conspicuous among the enemies of these insects, and also that it feeds upon no fewer than eight of the very worst lepidopterous pests.

Among the more widely known of these are the canker worms, which are very destructive to both orchards and woodlands. They often strip orchards so that they appear as if fire swept, and when their attacks are continued for a few years the trees die. The rose-breasted grosbeak devours both the spring canker worm (*Paleacrita vernata*, fig. 35) and the fall canker worm (*Alsophila pometaria*, fig. 27). Two birds collected in Illinois in May had fed upon the former caterpillar, while O. W. Knight testifies that in Pleasant Valley, Me., the birds actively attack the other.

The dreaded army worm (*Heliophila unipuncta*, fig. 28), which sometimes appears in myriads and devastate fields of grain and grass, also is the prey of this beautiful grosbeak. A bird from Illinois in July had captured 6 of these destructive caterpillars.

The tent-caterpillars are another group of noxious lepidopterous insects, which are common in many parts of the United States. They greatly damage orchards, as well as shade and woodland trees. E. H. Forbush[a] is authority for the statement that the rose-breasted grosbeak preys upon the orchard tent-caterpillar (*Malacosoma americana*, fig. 29), and Prof. C. M. Weed[b] reports that the bird devours moths, larvæ, and pupæ of the forest tent-caterpillar (*M. disstria*).

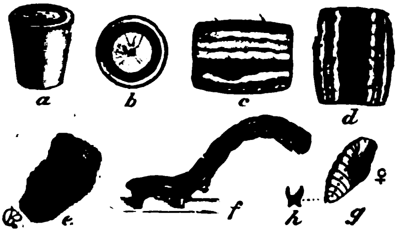

FIG. 27.—Fall cankerworm (*Alsophila pometaria*). (From Riley, Bureau of Entomology.)

Two other insects of this order, which are usually thought of together and which indeed are closely related, are the gipsy moth (fig. 30) and the brown-tailed moth (fig. 31). Mere mention of their names calls to mind the enormous damage done by them in the State of Massachusetts, and of the costly efforts being made to stamp out these disastrous invaders from across the sea. Birds have proved of service as allies in this struggle, and the present species is by no means least in importance among them. In the original report[c] on the gipsy moth, as well as in later publications,[d] the rosebreast is listed among the species devouring the larvæ, while in regard to the brown-tail moth Messrs. Mosher and Kirkland report[e] that "a rose-breasted grosbeak ate 57 caterpillars in twenty minutes."

FIG. 28.—Army worm (*Heliophila unipuncta*). (From Chittenden, Bureau of Entomology.)

This species eats hairy and spiny caterpillars as readily as smooth ones, and the idea so often advanced that such hairy armature is effective protection against the attack of birds receives little support from the food habits of the grosbeaks. Tussock and gipsy moths and both of the tent caterpillars are devoured, though very hairy. The browntail, the hairs of which so irritate human flesh, also is eagerly eaten, and other caterpillars clothed with spines were found in the stomachs examined. In several gizzards, indeed, a mass of branching caterpillar spines was all that remained to show the nature of the food. It is evident that neither hairs nor even pricking, stinging spines are adequate to protect a caterpillar from a hungry grosbeak.

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[a] Mass. State Bd. Agr. Rep. (1900), 1901, p. 315.

[b] N. H. Exp. Sta. Bull. 75, 1900, p. 121.

[c] Forbush, E. H., and Fernald, C. H., The Gipsy Moth, 1896, p. 219.

[d] Forbush, E. H., Mass. State Bd. Agr. Rep. (1900), 1901, p. 313.

[e] Forbush, E. H., Mass. State Bd. Agr. Rep., 1899, p. 322.

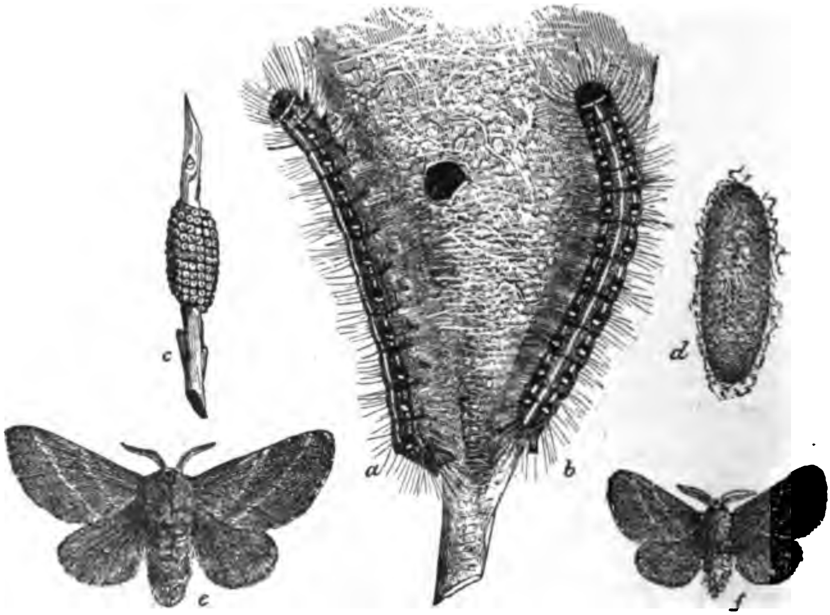

FIG. 29.—Orchard tent-caterpillar (*Malacosoma americana*). (From Riley, Bureau of Entomology.)

Besides Hymenoptera, Coleoptera, and Lepidoptera, which have been discussed in the order named, but one group of insects of importance in the dietary of the rosebreast remains, that of true bugs (Hemiptera), including the stink bugs, tree hoppers, plant lice, and scale insects. From this miscellaneous assemblage the grosbeak selects 3.89 per cent of its food, and two-thirds of this amount consists of the minute pests known as scale insects. From an economic standpoint also the latter are of greatest importance, as they rank among the worst enemies of agriculture in the United States. Orchards, both of the deciduous and citrus

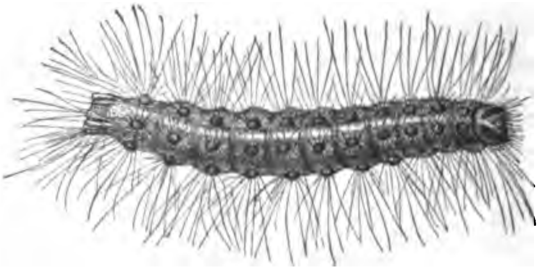

FIG. 30.—Gipsy moth caterpillar (*Porthetria dispar*). (From Bureau of Entomology.)

fruits, are most seriously affected, while shade and forest trees also suffer greatly.

Thirty-three of the rosebreasts examined had eaten scale insects, four kinds of which were identified. The plum scale (*Eulecanium cerasifex*), which is an occasional pest on cherry, apple, and pear, besides the tree from which it is named, seems to be relished. A female grosbeak collected in Indiana in May had consumed 36 plum scales, which constituted 95 percent of its food. Of two birds from Illinois, one ate 45 and the other more than 100 scales of this species, which composed 95 and 100 percent, respectively, of their stomach contents. Two nearly related species, the hickory scale (*E. caryæ*) and the tulip scale (*E. tuliferæ*), which latter sometimes seriously injures shade trees, also are devoured. Eleven grosbeaks ate unidentified species of the same genus of scale insects; two preyed upon the oak scale (*Kermes*), while the stomachs of 15 birds contained scale remains which defied determination.

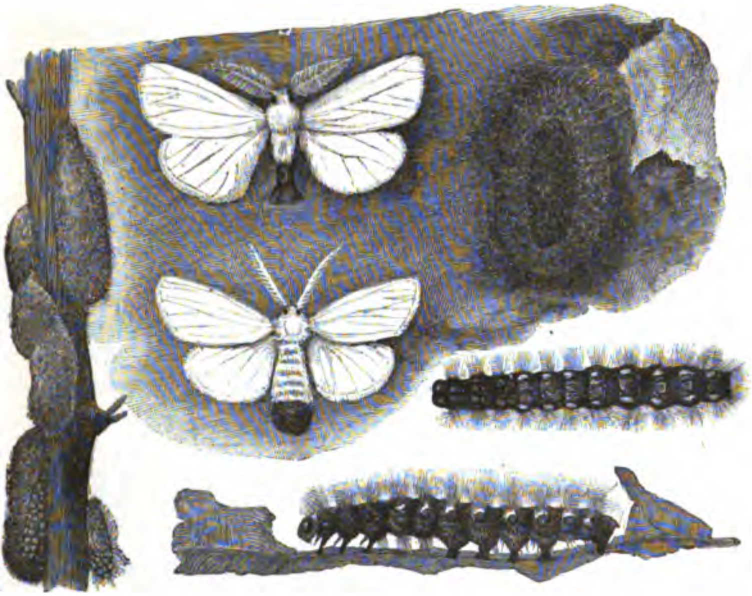

FIG. 31.—Brown-tail moth (*Euproctis chrysorrhoea*). (From Howard, Bureau of Entomology.)

The fact that birds exert a restrictive influence upon scales has remained almost unknown, these small insects being considered well protected from feathered enemies by their minute size and waxy secretions. Hence little attention has been paid to the subject, and the accounts of a few writers who announced the true relations of birds to scales were overlooked or ignored. Recent investigations have shown that many of our birds eat scales. The rose-breasted grosbeak is prominent among them, both because it eats a maximum number of species and because at times it makes scales a considerable part of its fare. These little pests can not have too many enemies for the good of mankind, and every bird that preys upon them should be welcomed and protected.

The rosebreast sometimes feeds upon plant lice (Aphididæ), especially those that live on birch; and a number of these fragile insects were found in a single stomach. Among other bugs, the odd little buffalo tree-hopper (*Ceresa bubalus*, fig. 32), and a few of the flower-bug and squash-bug families were found. Eight grosbeaks ate members of the stink-bug family. In feeding upon these insects the rosebreast gives further evidence of its indifference to flavors and odors which to us are repulsive and nauseating in the extreme. Two of the birds examined had devoured specimens of the banded soldier bug (*Milyas cinctus*), which preys upon many insects, including the potato beetle, and of another assassin bug (*Sinea diadema*), which preys upon cankerworms and other caterpillars, besides flies and bees, including the honey bee. Were the habit of devouring such bugs general, injury would result, but fortunately it is not. According to B. F. Gault, the rosebreast feeds upon the chinch bug, which at times has proved the worst crop pest in the country.

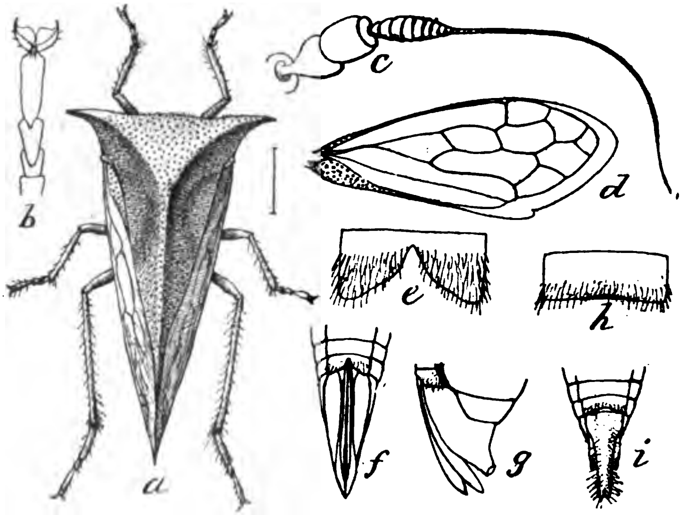

FIG. 32.—Buffalo tree-hopper (*Ceresa bubalus*). (From Marlatt, Bureau of Entomology.)

A remarkable feature of the rosebreast's dietary is the few grasshoppers eaten. These nutritious insects, which are welcomed by almost all birds, compose only 0.2 percent of the food of the whole number of grosbeaks examined. Results from the present collection of stomachs may not represent a fair average, but as proportionate numbers of the individuals examined were secured in the grasshopper season the data indicates at least a well-defined tendency of the bird to neglect them. That it does not actually dislike grasshoppers there is sufficient proof, for John Bachman wrote to Audubon[a] that a caged specimen "ate grasshoppers and crickets with peculiar relish," and Samuel Aughey[b] examined two specimens collected during one of the historic invasions of the Rocky Mountain locust, each of which "had about a dozen of locusts in its stomach."

Comparatively little weight, however, attaches to these instances, since the conditions were unusual. It is worthy of note that the closely related blackheaded grosbeak similarly neglects grasshoppers. Four rosebreasts fed upon this class of insects, 2 securing the peculiar shield-back grasshoppers, in one case to the number of 6, which composed 85 percent of the stomach contents, while the other 2 birds had eaten an ordinary grasshopper and an orthopterous insect not identified.

The small quantity of animal matter not yet detailed comprises spiders and their egg-sacs, which were eaten by 3 grosbeaks, and insect eggs and a fly by 1 each. Only 1 bird of this species had eaten a snail, which indicates that the rosebreast cares less for this kind of food than does the cardinal.

MINERAL MATTER.

Mineral matter, estimated in relation to the entire stomach contents, averaged 6.3 percent. Besides the ordinary sand and fine gravel, fragments of fossil corals and crinoids had been utilized for grinding material.

NESTLINGS.

Of the total number of birds only 4 were young still being fed by their parents, but, as usual among species whose diet is mixed, the proportion of animal food to vegetable is much greater in the case of fledglings than of adults. These 4 young rosebreasts consumed 78 per cent of animal and 22 per cent of vegetable matter. The 2 that were out of the nest were more highly vegetarian, one having eaten 85 per cent of plant substances. The latter were a berry of rough-leaved dogwood, some blackberries, of which 45 pits were present, and a few other seeds. Of the animal food consumed by the 4 young birds, caterpillars compose 20 percent, among them being the larvæ of sphinx moths, most of which are injurious to agriculture. Almost 25 percent is composed of beetles of various families, including bronzy wood-borers, click-beetles, and leaf-beetles. Representing the last family are the species *Melasoma lapponica*, which injures willow and cottonwood windbreaks, and that noted pest the

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[a] Audubon, J. J., Birds of America, III, 1841, p. 211.

[b] First Ann. Rept. U. S. Ent. Comm., 1878, App. II, p. 32.

Colorado potato beetle. Two stomachs of nestlings contained this latter nauseous insect, larvæ being found in one, adults in another. Wasps composed almost half of the food of one fledgling, and a weevil and some small cocoons constituted the remaining animal matter.

Passing from these results of actual stomach examination to the experiences of observers, it should be noted that the rosebreast's habit of feeding its nestlings the larvæ of the potato beetle is frequently recorded. This fact is one of the best evidences of the importance of this beetle in the grosbeak's regimen. Prof. F. E. L. Beal[a] speaks of "a small potato field, which earlier in the season was so badly infested * * * that the vines were completely riddled. The grosbeaks visited the field every day, and finally brought their fledged young. The young birds stood in a row on the topmost rail of the fence and were fed with the beetles which their parents gathered." Prof. E. F. Hitchings, State entomologist of Maine, gives the following interesting note:

> Several years ago I observed a pair nesting in a clump of trees in * * * Waterville. A piece of potatoes was planted near by, and I watched the parent birds as they fed their young on the larvæ of the Colorado potato beetle. I examined the bills of the young and found them stained and even dripping with the juice of the insects. It took a great many young larvæ to satisfy them. (May 19, 1906.)

When we reflect that every year there are thousands of grosbeak families throughout the breeding range of the species doing exactly the same thing, it can not be doubted that they exert a marked effect on the numbers of the potato beetle.

The voracity of nestlings is proverbial, and their lusty appetites greatly enhance their value as destroyers of injurious insects. The number of insects eaten daily by nestlings has been recorded in the case of but few birds; hence we are fortunate in having E. H. Forbush's account of a study of the nestlings of the rosebreast:

> On June 12, 1899, Mr. Mosher watched the nest of a pair of rose-breasted grosbeaks from early morning to 5 p. m. * * * For the first half hour the old birds were so excited by his presence that the feeding of the young birds was interrupted, so that no notes were taken until 6 a. m., and none were taken after 5 p. m. The old birds visited the nest—

	Times.		Times.
Between 6 and 7	52	Between 12 and 1	32
Between 7 and 8	47	Between 1 and 2	38
Between 8 and 9	43	Between 2 and 3	41
Between 9 and 10	30	Between 3 and 4	22
Between 10 and 11	36	Between 4 and 5	58
Between 11 and 12	27		

> making altogether 426 visits during the portion of the day that they were watched. The food was mainly caterpillars of one kind or another, and there

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[a] Farmers' Bull. 54, 1904, p. 35.

were only four visits made by a parent bird when but one insect was fed to the young; they usually brought three or more. A bird often carries in this way from three to eleven or twelve small caterpillars in its mouth and beak at one time. Owing to the height of the nest above the ground, it was impossible to determine accurately the species of caterpillars brought to the young. A considerable portion of them were certainly leaf-rollers from the oak trees. It seems probable, then, that these two birds must have fed their young on that day at least 1,000 insects, mostly caterpillars. This certainly is a very moderate estimate of the number of insects destroyed in one day by the family when we take into consideration the food required by the old birds.[a]

Although in this particular instance the precise nature of the food was not ascertained, there is much evidence to show that the same pests are fed to the young which are eaten by adults.

SUMMARY.

Examinations of 176 stomachs of rose-breasted grosbeaks show that the food is composed of animal and vegetable matter in almost equal parts, the exact proportions being 52 and 48 percent, respectively. Of the portion of the diet gleaned from the plant kingdom, 5.09 percent is grain, 1.37 garden peas, and 19.3 wild fruit. A third of the grain eaten may possibly be pillaged from standing crops, but this is the only stage when injury by birds is not easily prevented. Even if the total amount of grain consumed is pilfered from cultivated fields, it does not warrant hostile acts against a bird otherwise so beneficial.

Wild fruit is greatly relished, but cultivated fruit is not damaged, and although budding is practiced to a certain degree practically no harm results.

The rosebreast preys to some extent upon such beneficial insects as parasitic Hymenoptera, ground beetles, ladybirds, and fireflies. Only a tenth of the animal food is of this character, however, while among the remaining nine-tenths, which consists almost exclusively of injurious insects, is included a large number of formidable pests. Among these are the cucumber beetles, the hickory borer, plum curculio, Colorado potato beetle, Rocky Mountain locust, spring and fall cankerworms, orchard and forest tent-caterpillars, tussock moth, army worm, gipsy and brown-tailed moths, and the chinch bug. The bird is known as an active enemy of the cankerworm and the army worm during their extraordinary infestations, and was among the birds which preyed upon the Rocky Mountain locust and the gipsy moth at the height of their destructiveness.

Few birds have so good record both as to the large number of important pests attacked and the slight amount of damage done.

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[a] Forty-seventh Annual Report Mass. State Board of Agriculture (1899) 1901, p. 325.

LIST OF SEEDS, FRUITS, OTHER VEGETABLE SUBSTANCES, AND INVERTEBRATES EATEN BY THE ROSE-BREASTED GROSBEAK.

CULTIVATED PLANTS.

- Corn (*Zea mays*).
- Oats (*Avena sativa*).
- Wheat (*Triticum vulgare*).
- Cherry (*Prunus cerasus*).
- Peas (*Pisum sativum*).

WILD FRUITS.

- Mulberry (*Morus rubra*).
- Pokeberry (*Phytolacca decandra*).
- Sweet gum (*Liquidambar styraciflua*).
- Blackberry (*Rubus* sp.).
- Strawberry (*Fragaria* sp.).
- Juneberry (*Amelanchier canadensis*).
- Red haw (*Crataegus* sp.).
- Wild red cherry (*Prunus pennsylvanica*).
- Choke cherry (*Prunus virginiana*).
- Wild black cherry (*Prunus serotina*).
- Redbud (*Cercis canadensis*).
- Supple-jack (*Berchemia scandens*).
- Rough-leaved cornel (*Cornus asperifolia*).
- Checkerberry (*Gaultheria procumbens*).
- Nightshade (*Solanum* sp.).
- Sweet elder (*Sambucus canadensis*).
- Red-berried elder (*Sambucus pubens*).

BUDS AND FLOWERS.

- Cottonwood (*Populus* sp.).
- Post oak (*Quercus minor*).

WEEDS.

- Green foxtail (*Chætochloa viridis*).
- Sedge (*Carex* sp.).
- Knotgrass (*Polygonum aviculare*).
- Pale persicaria (*Polygonum lapathifolium*).
- Pennsylvania persicaria (*Polygonum pennsylvanicum*).
- Black bindweed (*Polygonum convolvulus*).
- Dock (*Rumex* sp.).
- Pigweed (*Amaranthus* sp.).
- Bloodroot (*Sanguinaria canadensis*).
- Wild radish (*Raphanus sativus*).
- Touch-me-not (*Impatiens biflora*).
- Dodder (*Cuscuta* sp.).
- Blue vervain (*Verbena hastata*).
- Giant ragweed (*Ambrosia trifida*).

COLEOPTERA.

- Ground-beetles (Carabidæ):
  - *Pasimachus depressus.*
- Ladybirds (Coccinellidæ):
  - *Chilocorus bivulnerus.*
  - *Brachyacantha ursina.*
- Histeridæ:
  - *Hister* sp.
- Nitidulidæ:
  - *Ips fasciatus.*
- Click-beetles (Elateridæ).
- Bronzy wood-borers (Buprestidæ):
  - *Chalcophora virginiensis.*
  - *Dicerca obscura.*
- Fireflies (Lampyridæ):
  - *Ellychnia corrusca.*
  - *Photinus pyralis.*
  - *Podabrus tomentosus.*
  - *Telephorus bilineatus.*
  - *Telephorus carolinus.*
  - *Telephorus rotundicollis.*
- Lamellicorn beetles (Scarabæidæ):
  - *Aphodius fimetarius.*
  - *Aphodius granarius.*
  - *Aphodius inquinatus.*
  - *Dichelonycha elongata.*
  - *Lachnosterna* sp.

COLEOPTERA—continued.

Lamellicorn beetles—Continued.
- *Cotalpa lanigera.*
- *Euphoria fulgida.*

Long-horned beetles (Cerambycidæ):
- *Phymatodes varius.*
- *Cyllene pictus.*
- *Leptura* sp.

Leaf-beetles (Chrysomelidæ):
- *Orsodachna atra.*
- *Cryptocephalus 4-maculatus.*
- *Griburius equestris.*
- *Typophorus canellus.*
- *Nodonota tristis.*
- *Leptinotarsa decemlineata.*
- *Chrysomela* sp.
- *Calligrapha bigsbyana.*
- *Calligrapha philadelphica.*
- *Melasoma lapponica.*
- *Diabrotica 12-punctata.*

Leaf-beetles—Continued.
- *Diabrotica vittata.*
- *Odontota dorsalis.*
- *Odontota nervosa.*

Scarred snout-beetles (Otiorhynchidæ).

True snout-beetles (Curculionidæ):
- *Sitones* sp.
- *Phytonomus* sp.
- *Hylobius pales.*
- *Conotrachelus albicinctus.*
- *Conotrachelus juglandis.*
- *Conotrachelus nenuphar.*
- *Ampeloglypter sesostris.*
- *Balaninus nasicus.*

Brenthidæ:
- *Eupsalis minuta.*

Bill-bugs (Calandridæ):
- *Rhodobænus 13-punctatus.*

HEMIPTERA.

Tree-hoppers (Membracidæ):
- *Ceresa bubalus.*

Scale insects (Coccidæ):
- *Kermes* sp.
- *Eulecanium caryæ.*
- *Eulecanium cerasifex.*
- *Eulecanium tulipiferæ.*

Plant lice (Aphididæ).

Stink bugs (Pentatomidæ).

Coreidæ.

Plant bugs (Capsidæ).

Assassin bugs (Reduviidæ):
- *Sinea diadema.*
- *Milyas cinctus.*

ORTHOPTERA.

Short-horned grasshoppers (Acridiidæ):
- *Tettix* sp.

LEPIDOPTERA.

Hawk moths (Sphingidæ).

Owlet moths Noctuidæ):
- *Heliophila unipuncta.*

Span worms (Geometridæ):
- *Paleacrita vernata.*

HYMENOPTERA.

Short-tongued bees (Andrenidæ).

Cuckoo-flies (Chrysididæ):
- *Chrysis* sp.

Smooth-headed ants (Formicidæ):
- *Camponotus* sp.

Saw-flies (Tenthredinidæ).

OTHER INSECTS.

Two-winged flies (Diptera).

OTHER INVERTEBRATES.

Spiders (Araneida).

Snails (Gastropoda).

BLACK-HEADED GROSBEAK.

(*Zamelodia melanocephala.* Plate III.)

APPEARANCE, DISTRIBUTION, AND HABITS.

In form and size the black-headed grosbeak is almost a counterpart of the last species, but it is very different in color. In the male blackhead, golden brown and lemon yellow take the place of the rose and white of the rosebreast; while the color of the underparts of the female is not soiled white, as in the eastern bird, but bright buffy. Both sexes of the western grosbeak have a horn-colored beak; that of the rosebreast is white.

Occupying a range from the west coast eastward which is complementary to, although slightly overlapping that of its eastern relative, the blackhead occurs from lowermost Mexico to southern British Columbia, northern Montana, western North Dakota, and northeastern Nebraska. It breeds at both extremes, and withdraws in winter to the southern third of its range, lingering as far north, however, as central Mexico.

The male is a brilliant songster, the peer of any of his kin. He is also an excellent mate and parent, and assumes an equal share of the labors of the nesting season. The nests of this species are loosely built and generally are placed in low growth, often along streams. The eggs are 3 or 4 in number and are similar to those of the rosebreast. The young are hatched in May and June. Since the bird often makes its home in higher altitudes it is sometimes called the mountain grosbeak.

ECONOMIC RELATIONS.

So great is the economic importance of the black-headed grosbeak that partial accounts of its food habits appear in two previous publications of the Biological Survey.[a] Only 70 stomachs were then available for examination, while more than three times that number[b] are now at hand, collected in five States and Territories. As the greater number are from California, the present report relates essentially to that State. The stomachs were collected from April to August, inclusive. The data show that about two-thirds of the bird's food consists of insects and other animal matter and one-third of vegetable substances. To be more exact, 65.85 percent is animal, 34.15 vegetable. The maximum amount (79.95) of animal matter is consumed in June. From the standpoint of the agriculturist great interest attaches to the vegetable food of this bird, as it is reputed to be destructive to cultivated fruit.

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[a] Farmers' Bull. 54, 1904, pp. 35–36; Yearbook Dept. Agr., 1904, pp. 246 and 248.

[b] About half of the total number of stomachs of this species were examined by Prof. F. E. L. Beal.

VEGETABLE FOOD.

Wheat and oats constitute but 2.08 and 1.83 percent, respectively, of the total food. Weed seeds and miscellaneous vegetable matter make up 9.28 percent, while fruit exceeds the sum of all these elements, and amounts to 20.96 percent of the entire subsistence, or almost two-thirds of the vegetable portion of the food. Fruit as an item of the bird's food assumes all the more importance because much of it is cultivated.

FRUIT.

Cultivated fruit that can be positively identified averages 9.85 percent of the contents of the 226 stomachs examined, and wild species 6.37 percent. In addition, 2.02 percent consisted of blackberries and raspberries, which may have been either wild or cultivated; 2.72 percent was undetermined fruit pulp of equally doubtful economic significance. It seems certain, therefore, that considerably more than half, perhaps two-thirds, of the fruit consumed by black-headed grosbeaks is from orchards and gardens. As this may be taken from a restricted region in a limited time, the item is of considerable importance in any locality where grosbeaks are numerous.

Moreover, no fruit, however large and tough-skinned, is proof against the massive beak of the blackhead, and the bird is likely to damage a great deal more than it eats because of its habit of leaving fruits after it has taken a single bite. Indeed, many of the fruits it attacks are so large that the bird could not swallow them entire. Apples, crabapples, peaches, apricots, pears, figs, plums, cherries, gooseberries, and blackberries are included in complaints of injury which have been received by the Survey and prunes and strawberries must be added to the number on the evidence of stomach examinations.

According to Professor Beal,[a] in California the depredations by the black-headed grosbeak cause it to be ranked about fourth in importance among fruit-eating birds. What this means will be better understood from account of the actual damage by the species. Prof. A. J. Cook gives the following instance:[b]

> A cherry grower at Ontario, Cal., reports the loss of half of a $4,000 crop of cherries from the depredations of birds in 1898. The birds in order of importance are *Piranga ludoviciana*, *Phainopepla nitens*, and the present species.

E. W. Nelson, of the Biological Survey, writes concerning his acquaintance with this grosbeak at Nevada City, Cal.:[c]

> I was told they were a great pest to fruit growers as they ate and destroyed a great many berries. This I proved by shooting several with their bills stained

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[a] Yearbook Department of Agriculture 1904, p. 246.

[b] California Cultivator, Aug., 1898, p. 253.

[c] Proc. Bost. Soc. Nat. Hist., 17, 1875, p. 359.

with blackberries and their crops full of them. I saw many of the berries which they had taken one bite from, leaving the rest.

In New Mexico the bird bears no better reputation, according to Jackson Tabor, of Folsom, who says:

> I have found the black-headed grosbeak to be very destructive to all kinds of vegetables and fruits. They made their first appearance in this country in the year 1888, and they came in swarms. * * * They destroyed the entire crop of gooseberries and commenced on crabapples, eating the apples off the top of the tree as I was picking them off the lower limbs. In the spring and early summer they take the cherries as fast as they get ripe, and the only remedy seems to be to wage a war of extermination against them. (September 2, 1903.)

Two stomachs were collected in Mr. Tabor's orchard on this date and both contained fruit, that in one stomach being identified as crabapple.

Following are the results obtained from the investigation of stomach contents: Cherries, both ripe and green, were selected by 41 of the grosbeaks examined, frequently composing from 45 to 95 percent of the stomach contents. All were identified by skins, not a seed being found, showing that the birds here and there bite into a cherry, destroying in this way many more cherries than if they satisfied their appetites by swallowing the fruit entire. Figs were next in order of preference, being devoured by 23 grosbeaks. In some cases they composed from 80 to 100 percent of the food. Among other fruits, remains of plums, crabapples, and apricots were found, each in one stomach, and strawberries in two. Unidentified fruit pulp and blackberries had been eaten by 23 birds. As noted above, it is uncertain whether these were cultivated or not, but probably the bulk were cultivated and should be charged against the bird.

Thus far our investigations have revealed nothing but injury by the bird, but, as will be shown later, the blackhead is not exclusively an enemy.

PROTECTIVE METHODS.—In connection with this subject there remains to be considered possible methods of reducing or altogether preventing loss from depredations by these birds. The plan usually suggested is the one mentioned in the above letter of Mr. Tabor, namely, "a war of extermination." This is generally effected by poisoning or shooting.

Aside from the fact that the justice of this method is open to serious question, there is the greater objection that innocent species often suffer equally with or even in greater degree than the marauder. In illustration we quote from Frank Stephens:[a]

> At Beale Spring both sexes were common and destroying quantities of fruit, to the great annoyance of the owner of the orchard, who employed an

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[a] Condor, V, 1903, p. 103.

Indian to shoot the birds. Unfortunately the Indian did not discriminate between the noxious and harmless species.

When poisoning is resorted to as a means of defence the destruction of many beneficial birds is inevitable. Nevertheless, if the above methods are condemned the fruit grower is entitled to ask for an effective substitute. A device for the protection of a small number of trees, which can be applied on rather short notice, is bird netting. This was tested upon cherry trees some years ago at the Indiana Agricultural Experiment Station.[a] The netting was procured at a cost of 4 cents per square yard and 75 yards were required per tree, the latter having been set six years. The fruit produced in a single season paid for the netting, which with careful handling, it is said, will last for ten years or more. This method is practicable in the case of a few lawn or garden trees, or possibly even in small orchards, and is well worth trial by anyone who considers future as well as present fruit crops. For it is certain that in destroying grosbeaks we end the lives of creatures which do much to check serious insect enemies of fruit. In large orchards netting of course can not be used.

Killing the grosbeaks is a last resort to be tried only when every other measure has been tested and failed. It is the less excusable because a method is available which, even in the case of large orchards, yields far better results. This is the planting here and there of wild fruit-bearing trees and shrubs, by means of which almost complete protection to cultivated fruit can be assured.

The chief essential is that the decoy trees shall be early bearing species, for it is the universal testimony that almost all of the damage done is to early fruit. How this applies in California is made clear in the following account of Professor Beal's experience in Alameda County. In the numerous orchards in Cull's Canyon only one grosbeak was seen where a week before, the last few days in May, they were common. It was a fine illustration of what has been demonstrated before—that the first fruits are the ones most eagerly eaten by the birds. When the early cherries were ripening in the orchard birds were to be seen on all sides—grosbeaks, orioles, tanagers, linnets, and jays, with now and then a blackbird or a flicker; but in June only one grosbeak and a few jays were seen, though the later cherries were just in perfection and nobody was disturbing the birds. A natural question is: Why are the later fruits comparatively immune to the attacks of birds? It may be urged that the feathered robbers get enough, that their appetites flag. While perhaps true of some birds, satiety in no way explains the facts concerning the black-headed grosbeak, since this bird consumes twice as much fruit in July and August as in May, though the quantity secured from cultivated sources is much less. It is evident that wild fruits are preferred, and that it is their abundance that protects the later ripening orchard varieties. In order to protect early cultivated fruit, therefore, it is necessary to plant decoy fruit trees which will come into bearing at the same time as the earliest varieties.

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[a] Troop, James, Bull. 53, Dec., 1894, pp. 125–126.

Such a fruit is the mulberry, which has long been known as a favorite of all frugivorous birds. There are many varieties derived from both foreign and native species, some one or other of which is suitable for any part of the United States. Perhaps the best of these to protect early fruit is the Townsend, which originated in northern Florida from the native red mulberry. This mulberry is very prolific and ripens fruit very early (in the latter part of March and April in Florida), a characteristic it will doubtless retain wherever it may be planted. Among other races of the same native stock are the Hicks, bearing in June and July, and the Stubbs, from June to August. The white mulberry of Asia (*Morus alba*) has yielded the Black English, the season of which is May to July, and the New American, fruiting at the same time, but very hardy, being adapted to mountain climates. The Russian mulberry (*Morus a. tatarica*) also is hardy, and bears in May and June. The suitability of the mulberry for California is affirmed by Prof. E. J. Wickson,[a] who says: "Nearly all varieties of the mulberry have been introduced in California and grown rapidly and thriftily." He commends the New American and Russian, mentioned above, and further states: "The mulberry has a long season. The Persian ripens in Tulare the last of May and continually thereafter until October."

Although the mulberry is an excellent fruit when fresh, it has been put to little use, the main reason no doubt being that it is not adapted to transportation. Since it is not of commercial importance, why not use it to protect more valuable fruits? The returns from such an investment, according to the testimony of many observers, are great. Dr. C. Hart Merriam says:[b]

> Groves of mulberry trees during the period of fruiting are thronged by hundreds if not thousands of birds, comprising many species and representing diverse groups. Such insectivorous kinds as flycatchers, warblers, vireos, and even cuckoos, form a part of the heterogeneous assemblage, departing from their customary diet long enough to join the multitude of blackbirds, orioles, finches, sparrows, tanagers, waxwings, catbirds, bluebirds, and thrushes, which from daylight until dark gorge themselves upon the tender berries. It seems incredible that such small birds as warblers, vireos, and the least flycatcher can open their tiny mouths wide enough to swallow such large berries as they really do gulp down with little effort. I know of no better tree than the mulberry to plant in public and private grounds for the purpose of attracting our resident birds.

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[a] California Fruits and How to Grow Them, San Francisco, 3rd ed., 1900, p. 398.

[b] Rept. Chief Div. Ornith. and Mamm. (1890), 1891, p. 285.

Further evidence of the attractive qualities of the mulberry is given by Dr. A. K. Fisher, who states that at his home in southern New York, a dark fruited, juicy Russian mulberry was a favorite food of a number of birds. Robins, catbirds, cedar birds, orioles, and to a less extent several other fruit-eating birds, fed by preference on mulberries, and rarely attacked cultivated cherries, which were abundant. In fact, as the period of mulberry ripening extended beyond the time of cherry harvesting, the more valuable fruit was almost completely protected from the depredations of birds.

The efficacy of the mulberry as a protection to cultivated fruits is fully confirmed also in a bulletin of the North Carolina Agricultural Experiment Station, which is exclusively devoted to the subject of mulberries:[a]

> They serve an excellent purpose near cherry trees and on strawberry plantations in attracting birds away from these fruits. As long as there are ripe mulberries close at hand, the other fruit will suffer very little from birds.

Such being the case, the several varieties of mulberries, on account of their great fruitfulness and the long bearing season, are well adapted to the protection of a wide range of fruit crops, including many of the later as well as the earlier ripening fruits.

Among other species valuable for the same purpose are certain inedible cherries. Mr. H. W. Henshaw informs the writer that a single tree of small sour cherries afforded almost complete protection to several trees of very fine cultivated cherries on the place of Mr. Joseph Palmer, near Washington. At the time a visit was made to this place, catbirds, robins, and orioles were abundant, and surprise was expressed that the crop of cherries was not molested. Pointing out a volunteer cherry tree, Mr. Palmer said: "There you see the reason; the birds will not touch the large cultivated cherries when the small ones are to be had."

Examination of this tree was made during the present year (1907). It proves to be the Mahaleb or Saint Lucie cherry (*Prunus mahaleb*). The 1907 crop of all kinds of cherries was very small, but as far as could be determined under the circumstances, the Mahalebs were preferred. In five minutes the writer noted in this tree 2 brown thrashers, 1 jay, 1 bluebird, 1 cedar bird, 1 kingbird, and 3 catbirds. All ate the fruit greedily. It appears that the birds must have cherries, though not the best varieties necessarily. Hence some such species as the Mahaleb is likely to afford more efficient protection than any other kind of fruit. It ripens with the cultivated cherries in this latitude and is very prolific, and since it is extensively imported for grafting stock it should be obtainable at low rates. The European bird cherry (*Prunus padus*), a most beautiful ornamental plant, also maturing fruit early, may be used to supplement the Mahaleb.

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[a] H. Hume and F. C. Reimer, No. 194, 1906, p. 56.

Other available trees and shrubs are juneberries, which fruit early, elderberries and blackberries for the summer, and a host, including native wild cherries, black and red haws, sumacs, and wild grapes, for the fall.

It may be objected by the orchardist that equal protection can be secured and, in addition, a saving of space be effected by simply increasing the number of fruit trees to allow for the loss by birds. It is doubtful, however, if this method would yield equivalent protection, since the injury would be widely distributed and some fruit spoiled on every tree; whereas decoy trees bearing the natural wild food of the birds will prove centers of attraction, and if they do not furnish enough fruit to satisfy the birds, the damage to the crop will be confined to a small number of trees in their immediate vicinity.

In this connection, in order to determine which are the best fruits to plant to draw the attention of the black-headed grosbeak, it is logical to consult the bird's own taste. We find elderberries far and away in the lead, they are eaten by a ninth of the whole number of birds examined and often compose from 70 to 100 percent of the stomach contents. Next in importance are blackberries, which have been discussed, and following these, juneberries (Pl. II, fig. 3), mulberries, and sumac fruits take equal rank. The bird is known to be fond also of the northwest black haw (*Cratægus douglasi*). It appears from the above facts that elderberries, juneberries, and mulberries are the most serviceable for diverting the attacks of the black-headed grosbeak from cultivated fruits.

In concluding this part of the subject it should be noted that although fruit is such a favorite food with the grosbeak, it constitutes only a limited part of the bird's diet, and that more than three times its bulk in injurious insects is eaten. Furthermore, the equivalent of three-fourths the amount of fruit is composed of other classes of vegetable matter, including weeds and grain.

GRAIN.

As has been stated above, wheat averages 2.08 percent of the stomach contents of the birds examined, and oats 1.83 percent. They were consumed by 8 and 10 grosbeaks, respectively. The bird rarely has been accused of injuring either grain, but we have a bit of testimony regarding its fondness for oats. Mr. S. H. Goodwin,[a] referring to newly sown fields in Utah, states:

> I have seen these birds in oat fields again and again, and have found them fairly stuffed with oats. But at most the damage is slight, for the birds are not sufficiently numerous to make them a serious factor in this direction, and the services rendered are many.

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[a] Deseret Farmer, III, 1907, No. 27, p. 8.

Oats may be injured later in the season when in the milk, as some were found in the stomach of a nestling blackhead. This grain, however, may have come from the abundant wild oats. In any case, the small percentage of grain consumed precludes serious injury under all but the most exceptional conditions.

WEED SEED AND OTHER VEGETABLE FOOD.

From April to August, inclusive, weed seeds constitute an average of 8.74 percent of the food of the blackheaded grosbeak. Most of the seeds are derived from noxious plants; hence their destruction is a service. Alfilaria (*Erodium*) seeds were taken by 13 birds, and chickweed (*Alsine*) by the same number. The little shining black seeds of red maids (*Calandrinia*) were eaten by 8 individuals, and the large fleshy akenes of the milk thistle (*Mariana*, Pl. II, fig. 12) by 5. Professor Beal several times has observed blackheads feeding on the latter seeds, and the birds are known to be quite fond also of the similar seeds of the garden sunflower. Among other weed seeds found in the stomachs are tumbleweed (*Amaranthus*, fig. 18), smartweed (*Polygonum*, fig. 1), dock (*Rumex*), nightshade (*Solanum*), catchfly (*Silene*), geranium, and bur clover (*Medicago*).

A few miscellaneous things, such as spires and wads of grass, coniferous leaves, and galls, were present in a few stomachs.

Several items not detected in the stomachs examined are mentioned by other writers, and among them are garden peas, which it will be remembered are relished by the rosebreast also. Dr. J. A. Allen[a] wrote in 1872 that in Utah the blackhead is "called 'pea bird,' it being very fond of young peas, and is hence regarded as obnoxious."

Mr. Jackson Tabor, of Folsom, N. Mex., in connection with his description of the bird's depredations on fruit says:

> They commenced on early vegetables, took the pea crop in toto, and put in their work on everything in the garden, even eating green beans that I never knew anything else to touch. (September 2, 1903.)

The bird shares in a taste said by many to be characteristic of all grosbeaks, and Mr. Henshaw[b] in 1876, writing of the bird's habits in the middle region of the West, states that—

> It appears especially fond of the buds of various deciduous trees and plants, and the bills of many of those taken had been stained and gummed with their juices.

At times it feeds extensively on willow buds, according to Doctor Coues, and Mr. Ridgway says that in May, in Truckee Valley, Nevada, it was observed to feed on the buds of the greasewood.[c]

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[a] Bull. M. C. Z., III, 6, 1872, p. 168.

[b] Zool. Expl. West of 100th Meridian, V, 1876, p. 297.

[c] Geol. Expl. 40th Parallel, IV, Pt. III, 1877, p. 488.

ANIMAL FOOD.

Insects and other animal matter eaten by the black-headed grosbeak amount to almost twice the bulk of the vegetable food, or 65.85 percent of the total subsistence. These, then, should be regarded as the really staple foods of the species. While no single vegetable element was fed upon by more than 41 grosbeaks, certain items of the insect diet were chosen by more than a hundred, or over half of the birds examined. This fact suggests that if the majority of the insects preyed upon are noxious, the benefits conferred by the bird greatly outweighs the injury inflicted.

Coming, then, to the economic status of the insects devoured, it appears from the results of the examination of 226 stomachs that 3.37 percent of the bird's food consists of ground beetles, fireflies, and ladybirds, which usually are considered beneficial; 2.56 percent is composed of wasps, ants, bees, etc., some of which are very useful, some innocuous or harmful; and 1.17 percent is made up of a great number of unrelated items, largely of neutral import, which, owing to the fact that they are rarely eaten, have little significance. Thus 58.75 percent, or nearly three-fifths of the entire food, is composed almost wholly of insects which are a constant menace to agriculture.

Of the above classes the beneficial kinds deserve first consideration. The most important among them numerically are fireflies (Lampyridæ), which are almost uniformly carnivorous, both as larvæ and as adults. Since they do much to check the increase of many other insects, the destruction of large numbers would be injurious. Fifty-two of the grosbeaks examined had fed upon fireflies to the extent of 2.38 percent of the whole food. Both adults and larvæ were captured, from 5 to 19 of the former and from 12 to 30 of the latter being found in some stomachs.

Among other useful insects which are attacked by the blackhead are the ground beetles (Carabidæ). Nineteen grosbeaks ate them, and they amount to 0.99 percent of the food. Since so few of these beetles are captured and as certain of them at times feed upon plants, the injury is too slight to be noticed.

Three black-headed grosbeaks ate small ladybird beetles which prey upon scale insects and plant lice, two of them securing specimens of an Australian coccinellid (*Rhizobius ventralis*, fig. 33), which was introduced into California for the express purpose of destroying scale insects. If the grosbeak destroyed many of these beetles, the bird would have to be given a black mark, but when it is considered that the blackhead feeds upon scale insects a large part of the time (more than a fifth of its food consisting of scales), it is surprising that so few of the ladybirds are devoured.

Considerable liking, however, was shown for another group, the Hymenoptera, part of which at least are beneficial. The most useful members of this order are the parasitic Hymenoptera, which lay their eggs in the eggs or young of other insects. Remains of insects of this class from the stomach of one grosbeak were identified and they amounted to 22 percent of its contents. Two bees were found in another stomach, one of which was a worker honeybee. These are the only beneficial species of Hymenoptera from stomachs of this grosbeak positively identified, but it is probable that many of the unidentified forms belong in the same category. In all, 58 grosbeaks fed upon wasps, bees, and ants, very many of which selected large wasps, which were most probably workers of some social species the loss of which would not be noticed. Eleven blackheads ate ants, including both pupæ and adults, for which the birds are to be commended, as many ants are prejudicial to the interests of man.

Summing up the relations of the black-headed grosbeak to beneficial insects, Hymenoptera constitute 2.56 percent of the food, not all of which, as just noted, is to be set down against the bird. The wholly useful fireflies amount to 2.38 percent, the mainly beneficial ground beetles to about 1 percent, while the ladybirds are a mere trace. Thus only about 5 percent, or a little more, of the bird's food consists of insects the destruction of which is prejudicial to the welfare of man. Even were the bird not useful otherwise, this showing would hardly justify reprisals.

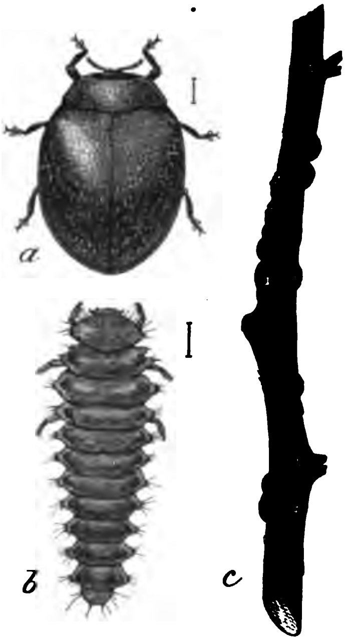

Fig. 33. — An Australian ladybird (*Rhizobius ventralis*). (From Marlatt, Bureau of Entomology.)

As a matter of fact, however, the blackhead is far from useless, since the remainder of the animal food, which is fully 11 times the bulk of the useful insects, consists of pests upon some of which no other bird is known to prey so extensively. Beetles of various families constitute about half the bulk of these harmful insects, and 28.71 percent of the total food. A much greater number of grosbeaks preyed upon leaf beetles (Chrysomelidæ) than any other family, these composing 17.98 per cent of the diet. One hundred and seventy-two blackheads, or almost four-fifths of the total number examined, captured leaf beetles, which are said to include among their ranks more enemies of crops, shade trees, and ornamental plants than any other family of beetles.

While this unmistakable preference for the often pungently flavored Chrysomelidæ is remarkable, it is still more surprising that of the 172 birds 103 selected a single species, the California flower-beetle (*Diabrotica soror*, almost indistinguishable from *D. 12-punctata*, fig. 26). This insect, according to Prof. Vernon L. Kellogg,[a] "does great damage as an adult by eating into the flower buds of roses, chrysanthemums, and a host of others, the larvæ feeding on the roots of alfalfa, chrysanthemums, and many other plants." Prof. E. J. Wickson adds,[b] it "is sometimes very injurious to early fruit by eating into it when ripe. The insect also eats leaves and blossoms. As the insect attacks the fruit just as it is ready to pick, it is impossible to apply any disagreeable or poisonous spray."

In connection with the latter testimony it is of interest to recall that the early fruits are the ones that the bird also injures most severely. Although less than 4 percent of the food, strictly speaking, can be called early fruit, and the total amount of cultivated fruit eaten during the bird's stay in California is only about 12 percent, the fruit-destroying flower-beetle, which it is impossible for man to combat effectually, constitutes more than 14 percent. In view of this fact alone, it would seem that the hand raised with deadly intent against the grosbeak when pilfering fruit may well be stayed. The beetles, though not so easy to see as the grosbeak, are present in countless hordes and busy at their destructive work. But the grosbeak finds and consumes more of them by actual bulk than of cultivated fruit. Furthermore, in view of the fact that 103 out of 226 black-headed grosbeaks preyed upon the flower-beetle, often securing from 8 to 21 each, and that 14.08 percent of the bird's entire food consists of these insects, it can be unhesitatingly stated that the black-head is one of the most important checks upon this pest.

While the grosbeak does not destroy any other insect to anything like the same extent that it does the flower-beetle, nevertheless it shows a considerable liking for some other leaf-beetles. Seventeen grosbeaks fed upon a species (*Melasoma scripta*) that is fond of the foliage of willows and poplars, and 15 devoured a dock-inhabiting leaf-beetle (*Gastroidea*), which sometimes eats pine needles; from 9 to 33 of these were found in a single stomach. About 37 grosbeaks ate leaf-beetles which could not be specifically identified.

The closely related family of long-horned wood-borers (Cerambycidæ) furnishes 2.29 percent of the bird's fare, and since the longicorns contain among their ranks numerous disastrous pests, the bird must be commended even for the moderate liking for them it displays. Click-beetles (Elateridæ), which in the larval state are known as wireworms, were devoured by 30 black-headed grosbeaks, but constitute only 0.77 percent of the food. Weevils also are sparingly consumed, which is in contrast to the avidity shown for them by most insect-eating birds. Twenty-five of the present collection of blackheads obtained specimens of these queer snouted beetles, but they compose less than 1 percent of the subsistence.

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[a] American Insects, 1905, p. 280.

[b] California Fruits and How to Grow Them, 1900, pp. 454–455.

Bronzy wood-borers (Buprestidæ) were captured by 8 grosbeaks, pine-feeding species being identified. Lamellicorn beetles (Scarabæidæ) fell a prey to 10 birds, but no important species were secured. A few blackheads obtained representatives of other coleopterous famlies, such as rove-beetles (Staphylinidæ), darkling beetles (Tenebrionidæ), and whirligig beetles (Gyrinidæ), one of which was found in a single stomach, though how the bird secured this aquatic species is a mystery. A quick tiger-beetle (*Cicindela*) also was found in a single stomach, and hence, although beneficial, it may be passed by without comment.

Coleopterous larvæ were eaten by 7 birds, 2 of which had secured representatives of the family Nitidulidæ. As these larvæ are too minute to have been eaten intentionally, and since they feed on decaying fruit, their presence among the stomach contents shows that the grosbeak also sometimes eats decayed fruit. Some of the fruit pulp, therefore, which could not be identified, but which was provisionally reckoned against the bird, is thus proven to have no value.

Grasshoppers, which are eaten by birds almost universally, are neglected by this species, as they are also by the rose-breasted grosbeak. Only 7 of the 226 blackheads examined had eaten them, and they constitute only 0.25 percent of the subsistence. Nevertheless, the black-headed grosbeak is included among the enemies of the Rocky Mountain locust by Samuel Aughey, who examined 2 specimens, one of which had eaten 8, the other 17 locusts.

Notwithstanding the blackhead is rather whimsical about a grasshopper ration, it shares the taste of most other birds for caterpillars, and it devours them and their chrysalids to the extent of 9 percent of its food. Spines and hairs, popularly supposed to be abhorred by birds, do not deter the blackhead, and sometimes all that is left in the stomach to tell of the capture of caterpillars is a mass of thorns and spines. Exactly 100 black-headed grosbeaks fed upon lepidopterous insects, 70 of them choosing caterpillars and 30 cocoons and chrysalids. It is among remains of the latter that we find representatives of the most important species in the order—the codling moth (fig 34). This pest is said to cause a loss of not less than $10,000,000 annually to the fruit growers of the United States. Inasmuch as the insect has no important parasites, its feathered enemies should be all the more appreciated, and it is safe to say that, with the probable exception of woodpeckers, the blackhead is the equal of any of them.

The codling moth is accessible to the grosbeak in two stages of its development, namely, when the larvæ are seeking a place to hibernate or pupate, as the case may be, and when they are in the chrysalis stage. By no means all of the birds examined had access to the species, yet 25 were successful in finding the pupæ or larvæ, and secured from 1 to 29 individuals, averaging about 5 each. It appears, therefore, that the grosbeak makes good use of its limited opportunities, and we agree with Professor Beal[a] that the "bird that helps to destroy this * * * insect, the curse of * * * apple culture, will be hailed as a blessing in spite of any shortcomings it may have."

Second in importance only to the above pest are cankerworms.

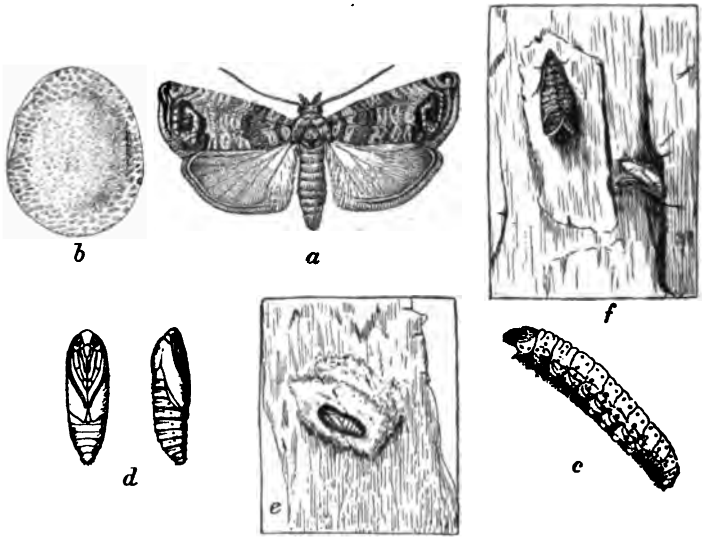

FIG. 34. Codling moth (*Carpocapsa pomonella*). (From Simpson, Bureau of Entomology.)

The spring cankerworm (*Paleacrita vernata*, fig. 35), which is responsible for a great deal of damage in apple orchards, constitutes 6 percent of the grosbeak's food in May. While this amount is not large, it is nevertheless worthy of note, since all of it is consumed when the earliest broods are developing.

Only one other order of insects contributes largely to the subsistence of the black-headed grosbeak—the true bugs, Heteroptera-Homoptera. Among minor items of the order the Heteroptera collectively form 1.05 percent of the diet, plant bugs, together with members of the squash-bug and stink-bug families and unidentified forms, being eaten by 18 birds. A miscellaneous assemblage from the other group (Homoptera), including leaf and tree hoppers, plant lice, and cicadas, was distributed among 9 of the grosbeaks examined, and composes a little more than 0.5 percent of the total food. Next is the family of scale insects (Coccidæ), which from an economic standpoint is the most important element of the black-headed grosbeak's food. Scale insects were fed upon by all but 81 of the 226 birds examined.

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[a] Yearbook Dept. Agr., 1904, p. 248.

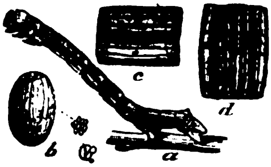


FIG. 35.—Spring cankerworm (*Paleacrita vernata*). (From Riley, Bureau of Entomology.)

The destructiveness of these insects need not be explained to anyone in the western fruit-growing region, where the disastrous effects of their presence have been keenly felt for many years, longer in fact than in any other part of the country. Suffice it to say that scale insects cause more trouble and loss to fruit growers than all other pests combined, and the damage from them is to be reckoned by millions of dollars.

The black-headed grosbeak evinces a distinct preference for the most widely distributed and abundant scale insect on the coast—the black olive scale (*Saissetia oleæ*, fig. 36) the importance of which the following notes from the writings of Prof. E. J. Wickson, of the University of California, will serve to show. It affects both citrus and deciduous trees, but is especially troublesome to the olive, and it will spread quickly to ornamental plants and vines. It is a very difficult scale to subdue, and in spite of the fact that immense numbers are killed by parasites it is still a grievous pest. This insect constitutes 20.32 per cent of the grosbeak's entire food, being eaten by 123 birds, many of which had secured from 12 to 32 scales each. If this service alone is not sufficient to atone for all the bird's depredations on fruit, the latter must be held at an exceedingly high price.

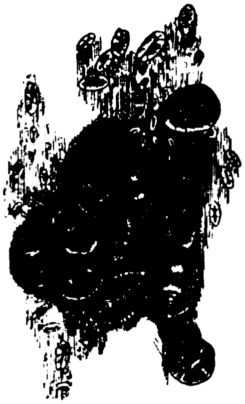


FIG. 36. — Black olive scale (*Saissetia oleæ*). (From Marlatt, Bureau of Entomology.)

Moreover, all has not yet been said in the bird's favor. It does not confine itself to the black olive scale alone, but at times probably preys extensively on other species. Sixteen other grosbeaks consumed enough scales to make up 2.26 per cent of the total food. Among the scales they ate are the brown apricot scale (*Eulecanium armeniacum*) and the frosted scale (*E. pruinosum*), both of considerable economic importance.

The remaining constituents of the animal food have slight percentage value. Fifteen grosbeaks devoured spiders or their cocoons, these items amounting to 0.34 percent of the entire regimen. Among other substances of little importance are snails, eaten by 14 birds, various unidentified insect pupæ by 10, eggshells by 5, and flies by 2; and, most remarkable for a bird of the blackhead's feeding habits, a bit of bone and the remains of a small fish were found in a single stomach each.

MINERAL MATTER.

The average percentage of mineral matter in the stomachs of the whole number of birds examined is 2.35. The nestlings of 2 or 3 days' age had none; those of a week, 6.57 percent; and those of 2 weeks, only 3 in number, however, had 2.33 percent.

NESTLINGS.

We are fortunate in having a fair amount of material to illustrate the food habits of the nestling black-headed grosbeaks. The nestlings at hand are readily divisible into three groups, separated both by age and character of the diet. Ten, comprising two broods of 3 each and one of 4, which were collected at the age of 2 and 3 days, had been fed animal matter exclusively. Seven, made up of two broods, numbering 3 and 4 individuals, respectively, had reached the age of 7 and 8 days, at which period a small amount, namely, 2.1 percent, of vegetable food had been introduced into the dietary, while 3 scattered fledgelings of a fortnight's growth consumed an average of 13.3 percent of vegetable substances, mainly fruit.

Two-thirds of the food of the youngest or entirely insectivorous group consisted of caterpillars, much over half of which, to wit, 37.2 percent, was spring cankerworms (*Paleacrita vernata*, fig. 35). In addition, 18 percent was composed of pupæ of the codling moth (fig. 34), which, indeed, were fed to part or all of each brood, including 8 of the 10 nestlings. If the habit of feeding these important pests, on the scale here indicated, to nestlings, whose never-ceasing demands for food are proverbial, is general, the amount of destruction wrought in their ranks is almost incalculable. Besides the codling moth and cankerworm, the flower-beetle and black olive scale also figure in the diet of this lot of youngsters; and longicorn beetles, spiders, leafhoppers, other bugs, and ant pupæ likewise were consumed.

One brood of the second group, which was just being initiated into the use of vegetable food, was given oats in the milk, while the other family was entirely carnivorous. More hard-bodied insects are fed at this age, beetles composing three-fourths of the whole diet, and over 23 percent was contributed by the flower-beetle alone. Black olive scales are most important among the remaining elements, 12 percent being composed of these pests. Hymenoptera, caterpillars, spiders, and insect eggs also were taken, and each of the members of one brood had a few bits of eggshell in its stomach.

Caterpillars again enter into the diet of the two-weeks old fledgelings, composing 45 percent of the whole amount, 21 percent being cankerworms. Black olive scales are 7 percent, and beetles, including lamellicorns, ground and click beetles, compose 26 percent of the food, the remaining animal elements being Hymenoptera and snails. The vegetable matter, 13.3 percent of the whole food, consists of cherries, strawberries, blackberries, bits of wheat, a few seeds, and spires and wads of grass, which last-named articles curiously enough are found in the stomachs of many other nestling birds.

The oldest fledgelings thus approximate more nearly in diet to that of the adults, even partaking of their fruit-eating habits. It is evident also, from the study of nestling blackheads, that vegetable matter is fed in gradually increasing quantities, corresponding, probably, either as cause or effect, to the growing muscular development of the stomach. Some grosbeaks observed by Professor Beal fed their nestlings only two to five times per hour, but as the feeding was accomplished by regurgitation it is probable that the stomachs of the young were practically filled during every visit to the nest.

Reviewing, it has been noted above that the nestlings of the black-headed grosbeak are fed a great number of codling moth pupæ, cankerworms, flower-beetles, and black olive scales, the destruction of which is greatly to the advantage of agriculture. When very young their food is entirely animal, and consists in great part of these grievous insect pests.

SUMMARY.

Examination of 226 stomachs of the black-headed grosbeak, the majority of which were collected in California, shows that during six months' stay in its summer home the bird consumes on the average 34.15 percent of vegetable and 65.85 percent of animal food.

Reports that the bird damages cultivated fruit are fully sustained by stomach examinations, figs and cherries appearing to be the kinds most injured. From 10 to 15 per cent of the food consists of cultivated fruits; a slightly smaller amount is weed seed, while the proportion of grain devoured is trifling.

It has been brought out that small orchards may be economically protected by means of bird netting. Large orchards may be protected in great measure by planting here and there suitable decoy trees, as mulberries.

Aside from the fact that ravages by the grosbeak may be prevented or greatly reduced without destroying the birds, it is evident that their general services to agriculture are so valuable that their destruction is not to be considered. It is to be noted: First, that the animal food of the blackhead, consisting almost wholly of injurious insects, is practically twice the bulk of the vegetable food, or more than four times that portion which is pilfered from man. Second, that the bird could not possibly select insects more prejudicial to the interests of western horticulture than the ones forming its natural food. These include the codling moth, cankerworms, flower-beetles, and such scale insects as the frosted, apricot, and black olive scales. Finally, these formidable fruit destroyers alone, not to mention 20 percent of other injurious insects, compose two-fifths of the entire amount of the black-headed grosbeak's food from April to September, or at least three times as much by actual bulk as the fruit consumed. In other words, for every quart of fruit eaten, more than 3 pints of black olive scales and more than a quart of flower-beetles, besides a generous sprinkling of codling moth pupæ and cankerworms fall prey to this grosbeak.

LIST OF SEEDS, FRUITS, AND INVERTEBRATES EATEN BY THE BLACK-HEADED GROSBEAK.

GRAIN.

Oats (*Avena sativa*).
Wheat (*Triticum vulgare*).

CULTIVATED FRUITS.

Fig (*Ficus carica*).
Mulberry (*Morus* sp.).
Strawberry (*Fragaria vesca*).
Blackberry (*Rubus* sp.).
Crabapple (*Malus prunifolia*).
Apricot (*Prunus armeniaca*).
Cherry (*Prunus cerasus*).
Prune (*Prunus domestica*).

WILD FRUITS.

Juneberry (*Amelanchier* sp.).
Poison oak (*Rhus diversiloba*).
Nightshade (*Solanum nigrum*).
Elderberry (*Sambucus* sp.).

WEEDS.

Dock (*Rumex* sp.).
Smartweed (*Polygonum* sp.).
Pigweed (*Amaranthus* sp.).
Red maids (*Calandrinia menziesi*).
Catchfly (*Silene* sp.).
Chickweed (*Alsine media*).
Cranesbill (*Geranium* sp.).
Alfilaria (*Erodium* sp.).
Bur clover (*Medicago denticulatum*).
Milk thistle (*Mariana mariniana*).

COLEOPTERA.

- Tiger beetles (Cicindelidæ):
    - *Cicindela* sp.
- Ground beetles (Carabidæ):
    - *Platynus variolatus.*
- Whirligig beetles (Gyrinidæ).
- Rove beetles (Staphylinidæ).
- Ladybird beetles (Coccinellidæ):
    - *Psyllobora tædata.*
    - *Rhizobius ventralis.*
- Nitidulidæ.
- Click-beetles (Elateridæ):
    - *Megapenthes elegans.*
- Bronzy wood-borers (Buprestidæ):
    - *Buprestis lineata.*
    - *Buprestis fasciata langi.*
    - *Acmæodera gibbula.*
- Fireflies (Lampyridæ):
    - *Podabrus* sp.
    - *Telephorus consors.*
    - *Telephorus divisus.*
- Lamellicorn beetles (Scarabæidæ):
    - *Aphodius inquinatus.*
    - *Euphoria* sp.
- Long-horned beetles (Cerambycidæ):
    - *Leptura militaris.*
- Leaf beetles (Chrysomelidæ):
    - *Syneta albida.*
    - *Gastroidea cyanea.*
    - *Melasoma scripta.*
    - *Diabrotica soror.*
    - *Diabrotica trivittata.*
- Darkling beetles (Tenebrionidæ).
- Rhynchitidæ:
    - *Deporaus glastinus.*
- Scarred snout-beetles (Otiorhynchidae):
    - *Scythropus californicus.*
- True snout-beetles (Curculionidæ):
    - *Dorytomus hispidus.*
    - *Baris* sp.
    - *Balaninus* sp.

HEMIPTERA.

- Cicadas (Cicadidæ):
    - *Cicada* sp.
- Tree-hoppers (Membracidæ).
- Scale insects (Coccidæ):
    - *Saissetia oleæ.*
    - *Eulecanium armeniacum.*
    - *Eulecanium pruinosum.*
- Leaf-hoppers (Jassidæ).
- Jumping plant-lice (Psyllidæ).
- Plant-lice (Aphididæ).
- Stink-bugs (Pentatomidæ).
- Coreidæ.
- Plant-bugs (Capsidæ).

ORTHOPTERA.

Short-horned grasshoppers (Acridiidæ).

LEPIDOPTERA.

- Spanworms (Geometridæ):
    - *Paleacrita vernata.*
- Leaf-rollers (Tortricidæ):
    - *Carpocapsa pomonella.*

HYMENOPTERA.

- Apidæ (*Apis mellifera*).
- Rough-headed ants (Myrmicidæ).

DIPTERA.

Borboridæ (*Borborus* sp.).

OTHER INVERTEBRATES.

- Spiders (Araneida).
- Snails (Gastropoda).

BLUE GROSBEAK.

(*Guiraca cærulea*, Plate IV.)

APPEARANCE, DISTRIBUTION, AND HABITS.

While less strikingly colored than other grosbeaks, this species equals them in beauty. The general color of the male is ultramarine, but the tail and wings are black, with bars of chestnut crossing the latter. The female is much duller. Brownish above and below, with a lighter throat, she bears a marked superficial resemblance to the female cowbird, and the massive bill is the only conspicuous feature that serves to distinguish the two.

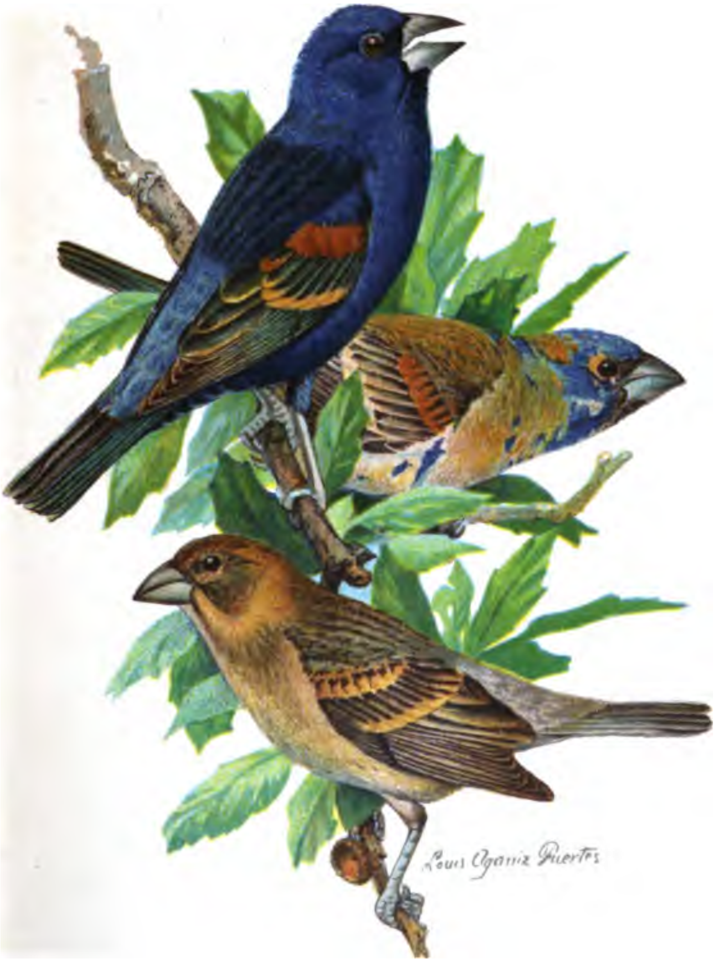
This is the smallest of the grosbeaks, and occupies a wider range in the United States than any of the others. There are two subspecies of blue grosbeaks, the western one breeding from southernmost Mexico to northern California and southern South Dakota and the eastern from the gulf coast to southern Pennsylvania and southeastern Nebraska. The two races merge in eastern Texas, Oklahoma, and Kansas. In winter both withdraw entirely from the United States.

During the breeding season the blue grosbeak is locally abundant in the southern and western parts of its range, being in some places a familiar garden and orchard bird. In the eastern part of the Mississippi Valley, however, and in the Atlantic States, it is shy, retiring, and generally rare.

In the latter regions the nest is usually placed in a low bush or vine in a thicket; but where the birds are more common they build in fruit trees or even in cultivated ornamental plants about houses. Everywhere the species nests late. The eggs are 3 or 4 in number and are bluish white; two broods are raised in the south and one in the north. In common with all its relatives, this handsome bird is a good singer, and its song, though weak, suggests the rosebreast's lovely carol. Its pleasing song and engaging appearance have made the grosbeak a favorite cage-bird among the southern creoles, who know it as the "blue pop."

ECONOMIC RELATIONS.

The present investigation of the food habits of this species concerns only summer residents of the United States. Fifty-one stomachs have been examined, which were collected in every month from April to September, inclusive, and in seven States and the District of Columbia. Of the food they contained 67.6 percent is animal matter and 32.4 percent vegetable. No month is represented by more than 19 birds; hence the results obtained are by no means as reliable as could be desired. However, as the economic relations of the blue grosbeak are almost entirely unknown, even these tentative findings have a distinct value.



BLUE GROSBEAKS.

[Top figure, adult male; middle figure, immature male; bottom figure, female.]

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VEGETABLE FOOD.

The proper valuation of the vegetable elements of a bird's food is of great importance, since upon this point largely depends the attitude of the agriculturist toward the bird. The main question is, Does the blue grosbeak appropriate an undue amount of the product of field, orchard, and garden crops?

Vegetable substances consumed by the blue grosbeak and constituting 32.4 percent of its food may be classified as follows: Grain, 14.25 percent; weed seed, 18.05 percent; fruit, 0.06 percent; and miscellaneous. 0.04 percent.

FRUIT.

From present information it appears that cultivated fruits are not molested by the blue grosbeak. All writers agree that the little fruit eaten is wild, a conclusion supported by the results of the present examination. Only two birds, both young, had eaten fruit of any kind, and in each case it consisted of a few bits of blackberry, undoubtedly wild.

GRAIN.

Grain constitutes 14.25 percent of the food of the birds examined. Wheat was eaten by 6 of the total number, and amounts to 8.33 percent of the entire subsistence. Corn was eaten by 4 birds and is 4.87 percent of the food, while oats, which form 1.05 percent, were consumed by only 2 of the 51 birds. Probably all this grain was obtained from cultivated crops.

One grosbeak, collected in a wheat field in June, had eaten enough of the milky cereal to make up 40 percent of its stomach contents. Three others from the same region in the same and the succeeding two months had devoured wheat, which shows that this grain is relished even in the riper stages.

Apparently the corn in the stomachs also came from the standing crop, and while the blue grosbeak seems too small to be an active depredator of such a well-protected grain, yet with its powerful beak there is no doubt that it can as readily shear through the enveloping husks as crack the kernels themselves. Referring to this latter point, Wilson says of a captive bird: "I fed it on Indian corn, which it seemed to prefer, easily breaking with its powerful bill the hardest grains." Notwithstanding this the bird does little damage. At all events, no complaints of injury have been made.

There is testimony, however, that the bird does some mischief in oat fields. Doctor Fisher, of the Biological Survey, has seen flocks feeding upon this cereal in Nebraska and in California, and the same habit has been observed in Virginia. In general this occurs late in summer. After the nesting season blue grosbeaks change their habits greatly. The once timorous birds leave off their shyness; the isolated families assemble, and flocks, usually small, but sometimes large, raid the grain fields. Oats and rice especially are injured by them. Concerning the effect of the blue grosbeak upon rice in Louisiana, Mr. George Beyer[a] says: "In the Florida parishes * * * it is generally called 'rice bird.' Flocks of thousands descend upon the ripe rice during August and September." As noted above, oats were found in 2 stomachs examined during the present investigation, rice in none.

Summary.—Only 11 of the 51 blue grosbeaks examined had eaten grain, from which it is evident that this food is not specially sought, even when accessible. Grain constitutes 14.25 per cent of the total food, but only one bird ate grain exclusively. Considering only the 11 cereal feeders, we find they were satisfied with a fare of half grain, and preferred to eat insects and other food along with it. It seems, therefore, that in summer this grosbeak does not evince a decided taste for grain, and, being widely and sparingly distributed, it is inconceivable that noticeable loss can be caused by it.

That the reverse is true later in the year is well established, but the injury then committed seems to be of no great importance, or it would have attracted more attention. It is certain that the blue grosbeak is not for an instant to be ranked with such well-known grain pests as the bobolink and some of the blackbirds, and the cases of serious injury attributable to it are clearly of rare occurrence and brief duration.

Moreover, during by far the greater part of the bird's stay in the United States its food habits are decidedly beneficial, and it consumes almost five times as great a bulk of injurious insects as of grain. Without doubt the farmer could afford to pay for the destruction of these insects with grain in the reverse ratio and yet make a large profit by the bird's services.

WEEDS.

Weed seeds are consumed by the blue grosbeak during every month of its stay in the United States. They constitute 18.05 per cent of the total food, and thus are given preference over all other items of the vegetable regimen. Not a great variety of seeds are devoured, and more of foxtail (fig. 37) and bindweed (fig. 21) are taken than any others. It is well known that these weeds are among the most troublesome in America, striving constantly to overtop and crowd out cutivated plants, while bindweed during its earlier stages harbors the corn root-louse, one of the most injurious of grain pests. Practically all birds to any degree vegetarian feed upon the seeds of these weeds, a work of which the blue grosbeak assumes a proper share and the value of which in the aggregate is immense.

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[a] Avifauna Louisiana, New Orleans, 1900, p. 34.

Before leaving the subject of vegetable food, it should be mentioned that one blue grosbeak, collected in the District of Columbia, had fed largely upon the seeds of wild rice (*Zizania aquatica*). This plant is an important source of food for many larger birds, especially ducks and geese, but is not generally sought by the smaller species.

ANIMAL FOOD.

The blue grosbeak consumes more than twice as much animal as vegetable food, and it consists of snails, spiders, and various insects. The latter constitute 65.7 out of 67.6 percent, the entire amount, and while comprising for the most part injurious species, include a few forms generally considered useful. These will be discussed at once.

A certain family of ground-inhabiting beetles, the Carabidæ, on account of their predaceous habits, are usually classed as beneficial. They have been detected, however, feeding upon vegetable matter, and in many places even upon cultivated crops. These facts should make us slow to condemn a bird for picking up a few of them. The present species manifests very little liking for ground-beetles, only 4 birds of the entire number having taken them, and in no case did they constitute more than 10 per cent of the stomach contents.

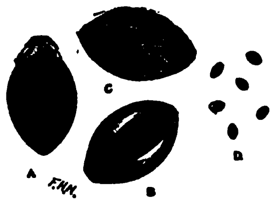

FIG. 37.—Seeds of green foxtail (*Chætochloa viridis*). (From Hillman, Nevada Experiment Station.)

One other predaceous insect was captured. This was a robber fly (Asilidæ). Flies of this family capture grasshoppers, beetles, other flies and bees, and at times do considerable mischief among honey bees. They are not wholly beneficial, therefore, although probably the balance is in their favor. If it is the rule, however, as appears from the present examination, that not more than 1 blue grosbeak in 50 takes a robber fly, the resulting damage need not disturb us.

Besides the insects of predatory habits, there are others which are useful as parasites. None of these were taken directly by any of the blue grosbeaks examined, but about 20 eggs of a parasite, probably a tachina fly, were attached to the body of a purslane caterpillar eaten by one of the birds. Had these parasitic flies been allowed to complete development they would have attacked and destroyed other caterpillars, but probably not so many as the grosbeak which fed upon them, one-tenth of whose food would have consisted of these creatures.

Caterpillars and adult lepidoptera (moths) compose 9.77 percent of the food of the blue grosbeak. The purslane caterpillar (fig. 38) mentioned above is eaten by adults and is fed also to the nestlings.

Ordinarily this insect is harmless, but occasionally it attacks garden and fruit crops, especially the sugar beet. Another caterpillar also, the cotton cutworm (*Prodenia ornithogalli*, fig. 9), which attacks the latter crop as well as the tomato and cotton, is devoured by the blue grosbeak. Four birds, taken in the cotton fields of Texas in May, had eaten 9 cotton cutworms, which constituted more than 40 percent of their food. Many other caterpillars also of the same family (Sphingidæ), as the purslane feeder, and two moths were consumed by the blue grosbeaks examined. Because of the injurious habits of these insects their destruction by the grosbeak is to be commended.

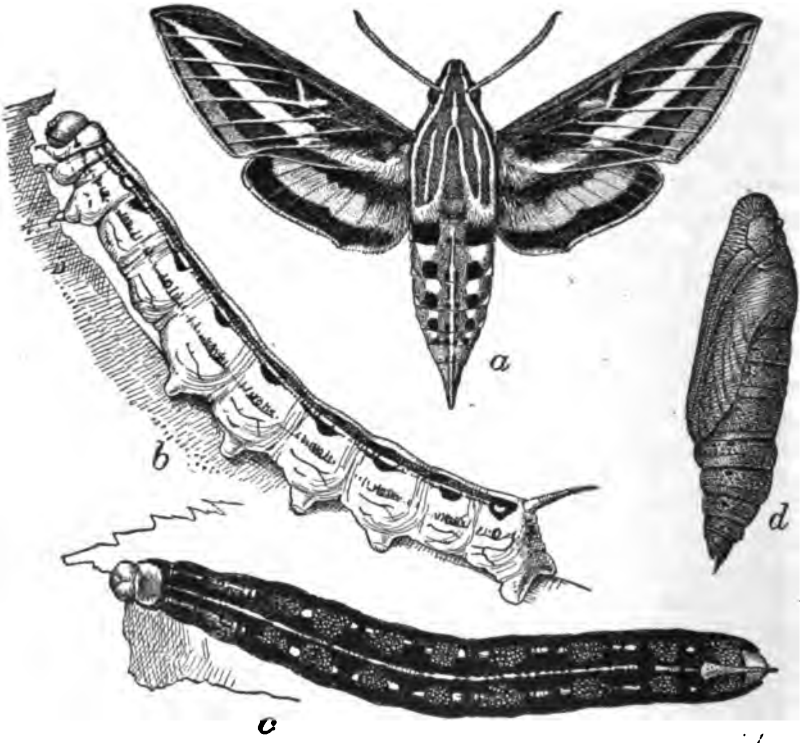

FIG. 38.—Purslane caterpillar (*Deilephila lineata*). (From Chittenden, Bureau of Entomology.)

The true bugs (Hemiptera) constitute another group of insects, mainly injurious, and all of them eaten by the grosbeak are destructive. These include members of the squash-bug family (Coreidæ), stink-bug family (Pentatomidæ), tree-hoppers (Membracidæ), and cicadas or harvest flies (Cicadidæ). One blue grosbeak from South Dakota had eaten 3 of the latter, which composed 94 percent of its stomach contents.

Injurious beetles comprise 24.4 percent of the grosbeak's food, almost half (11.25 percent) of which amount consists of members of the May beetle family (Scarabæidæ). Adult June bugs, and their larvæ, the white grubs, were devoured by some birds to the exclusion of other food, and 1 grosbeak had eaten 3 of the common dung-beetles (*Aphodius fimetarius*). Weevils are next in importance among beetles, and 7.18 percent of the bird's seasonal food was made up of these pests. Many of them were scarred snout-beetles (Otiorhynchidæ) and curculios (Curculionidæ); some of them certainly were injurious species. Two grosbeaks selected the conspicuously red and black colored billbug (*Rhodobœnus 13-punctatus*), each eating 2. Leaf-beetles (Chrysomelidæ), wood-borers (Buprestidæ), click-beetles (Elateridæ), and long-horned beetles (Cerambycidæ), nearly all of which are injurious, were also devoured.

The most important element of the animal food, however, is grasshoppers. Crickets and long and short horned grasshoppers are eagerly consumed, composing 27.2 percent of the total food. Thirty-two of the 51 blue grosbeaks ate them, several taking nothing else. They are fed to the nestlings in generous measure, and without doubt are the most important single article of diet. During one of the historic outbreaks of the Rocky Mountain locust, the blue grosbeak was found to feed on other grasshoppers among the swarming hordes, and it is certain that the pest itself was not overlooked. A very closely-related species, called in contradistinction the lesser migratory locust (*Melanoplus atlanis*, fig. 39), has been identified from the stomachs examined.

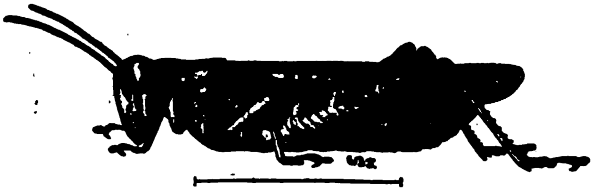

FIG. 39.—Lesser migratory locust (*Melanoplus atlanis*). (From Lugger, Minnesota Experiment Station.)

But little insect food in addition to that above discussed is consumed. A fly or a wasp is rarely secured, and one ant and a saw-fly larva were eaten. Besides insects, a small amount of other animal matter was present in the stomachs. Spiders or their egg-sacs were eaten by 2 birds and snails by 9. The latter may be taken in lieu of gravel.

Mineral Matter.

Only 2 adult blue grosbeaks out of a total of 38 had taken inorganic mineral matter, and the percentage of such material is only 0.63. Of 13 nestlings, 7 contained mineral matter in quantity sufficient to make the average for the whole group 8.3 percent, which is more than 13 times as much as the old birds take. So wide a discrepancy would seem to indicate that there is great difference between oid and young birds in the need for this material.

YOUNG.

Among the blue grosbeaks examined are 13 young collected in Kansas in July and August. Eight of these are nestlings, and 5 are young just out of the nests, but still being fed by their parents. The percentage of animal food for the 13 young birds is 99.08; of vegetable, 0.92.

Grasshoppers constitute 74.1 percent of the food. Among them are included the lesser migratory locust (*Melanoplus atlanis*) and a large coral-winged locust (*Hippiscus*, fig. 40). The remains of as many as 16 short-horned locusts were obtained from one stomach, while another contained 14. Caterpillars, among them the purslane sphinx, compose 10.7 percent of the subsistence of the nestlings, and snails 10 percent. The remainder of the animal food consists of a weevil, a long-horned beetle, a ground beetle, a robber fly, and the eggs of a tachina fly, which were on the purslane caterpillar. It is curious that so large a proportion of the beneficial insects consumed should be in the stomachs of nestlings, but it may be that these items, which ordinarily are rarely taken, are hurriedly gathered only because of the insistent demands of the hungry young.

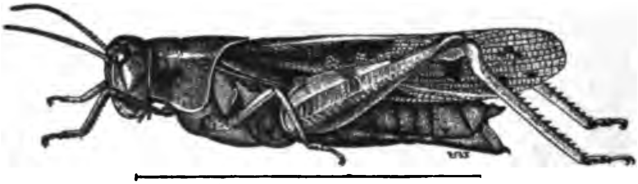

FIG. 40.—Coral-winged locust (*Hippiscus tuberculatus*). (From Lugger, Minnesota Experiment Station.)

The vegetable food consists of a few unidentified vegetable filaments and some slight remains of blackberries in two stomachs; this was the only fruit eaten by any of the birds, young or old.

SUMMARY.

Present data shows that the food of the blue grosbeak is 67.6 percent animal and 32.4 vegetable.

Grain constitutes 14.25 percent of the diet, but on account of the scattered distribution of the birds, no appreciable damage is done during most of the summer. Later, when they forage in flocks, they are said to do considerable injury. But, as noted above, the birds consume twice as much animal as vegetable matter, and even if all of the latter had been grain, instead of less than half, as is actually the case, it would have been paid for many times over.

Among the important insect pests eaten by the blue grosbeak are grasshoppers, weevils, the purslane sphinx, and the cotton cutworm. The species deserves protection for its destruction of grasshoppers alone, and when its food habits are considered in their entirety the showing unquestionably is greatly in favor of the bird.

LIST OF SEEDS, FRUITS, AND INVERTEBRATES EATEN BY THE BLUE GROSBEAK.

GRAIN AND FORAGE PLANTS.

- Corn (*Zea mays*).
- Oats (*Avena sativa*).
- Wheat (*Triticum vulgare*).
- Alfalfa (*Medicago sativa*).

WEEDS AND WILD FRUIT.

- Crab-grass (*Panicum* sp.).
- Yellow foxtail (*Chætochloa glauca.*)
- Green foxtail (*Chætochloa viridis*).
- Wild rice (*Zizania aquatica*).
- Rush grass (*Sporobolus* sp.).
- Smartweed (*Polygonum* sp.).
- Blackberry (*Rubus* sp.).

COLEOPTERA.

- Ground-beetles (Carabidæ).
- Click-beetles (Elateridæ).
- Leaf-beetles (Chrysomelidæ).
- Bronzy wood-borers (Buprestidæ).
- Lamellicorn beetles (Scarabæidæ):
    - *Aphodius fimctarius.*
    - *Lachnosterna* sp.
- Long-horned beetles (Cerambycidæ):
    - *Hippopsis lemniscata.*
- Scarred snout-beetles (Otiorhynchidæ).
- True snout-beetles (Curculionidæ).
- Bill-bugs (Calandridæ):
    - *Rhodobænus 13-punctatus.*

HEMIPTERA.

- Cicadas (Cicadidæ):
    - *Cicada* sp.
- Tree-hoppers (Membracidæ).
- Squash-bugs (Coreidæ).
- Stink-bugs (Pentatomidæ).

ORTHOPTERA.

- Short-horned grasshoppers (Acrididæ):
    - *Hippiscus* sp.
    - *Melanoplus atlanis.*
- Long-horned grasshoppers (Locustidæ).
- Crickets (Gryllidæ):
    - *Gryllus* sp.

LEPIDOPTERA.

- Hawk-moths (Sphingidæ):
    - *Deilephila lineata.*
- Owlet-moths (Noctuidæ):
    - *Prodenia ornithogalli.*

OTHER INSECTS.

- Smooth-headed ants (Formicidæ).
- Sawflies (Tenthredinidæ).
- Robber flies (Asilidæ).
- Tachina flies (Tachinidæ).

OTHER INVERTEBRATES.

- Spiders (Araneida).
- Snails (Gastropoda).

RELATIONS OF GROSBEAKS AND OTHER BIRDS TO PARASITIC INSECTS.

As in the previous pages mention is made of the fact that grosbeaks to some extent feed on parasitic insects, and as many other birds have the same habit, certain phases of the subject are here briefly discussed. Parasites are useful to man because they prey upon and reduce the numbers of injurious insects. Hence to the extent that birds diminish the number of parasites they are inimical to man's interests. But there is another aspect to the interrelations of birds, parasites, and injurious insects. The attacks of parasitic insects, however numerous they may be, do not result in the immediate death of their victims, since time is required for the development of the larvæ within or upon the body of the hosts. Hence the latter, after receiving the eggs which ultimately are to prove fatal, sometimes continue their depredations, and may in a few days ruin the season's crop. Under these circumstances the parasites do no immediate good, though they serve to prevent increase of the species attacked. It is quite otherwise with birds, which instantly stop depredations by killing the insects responsible for them. Often in a few days birds extirpate a pest over a limited area, and the crop, freed from its enemies, makes successful growth. It is true that at the same time all eggs and larvæ of parasites present in the host insects also are destroyed. Though this is regrettable, the effects of the loss of the parasites must be regarded as of secondary importance, since the main purpose—getting rid of the pests—is accomplished.

Precisely the same result follows the destruction of cocoons, the burning of caterpillar nests, fumigation by hydrocyanic gas (which is exceedingly destructive to all life), and wholesale killing by contact sprays (kerosene, whale-oil soaps, and the like). These methods of destroying insects are widely recommended and extensively used, resulting in the indiscriminate destruction of beneficial and injurious insects, foe and friend alike. Moreover, there is no doubt that in spite of their indiscriminate effect, these practices result in great good. As stated above, birds are chargeable with similar destruction of useful insects along with the injurious, but it is worthy of note that the effects of their feeding have not been judged from the same standpoint nor given the benefit of doubt accorded to the work of artificial agencies. However, since it has been suggested that birds may so reduce the number of parasitic insects as seriously to restrict their beneficial services, it may be profitable to inquire into the facts of the case. There is no record of an instance in which noticeable injury has been caused through the destruction of parasites by birds, and there is much evidence going to show that this never happens. First, taking up the order Diptera, to which belong the tachina parasites (such as were found in the stomach of one blue grosbeak), the data now available show that probably less than 3 percent of the food of birds in general consists of members of this order. And there is no reason to believe that parasitic forms of this or other orders are specially sought for by birds. Since the dipterous parasites are confined to three or four families of the three score in the United States, it is not likely that the part of the 3 percent of bird food they furnish results in much injury to agriculture.

Turning to that most important group, the Hymenoptera, it is to be noted that many of them are small, some being extremely minute (as is the case with a large group of the most effective parasites, the chalcis flies), and these are very rarely found in bird stomachs. A few families of Hymenoptera (Chrysididæ, Trigonalidæ, Sapygidæ, and Mutillidæ) are characteristically parasitic on other and useful members of the order. The destruction of any of these by birds (the cuckoo-flies are taken, at least occasionally) is a benefit. The same must be said of the capture of many species belonging to other families which are guilty of the same practice. They parasitize their beneficial relatives, often destroying a large proportion of them. Moreover, even the species usually beneficial do not always stick to their rôles, but sometimes parasitize species having the same as their own normal relation to the host. All of these things tend to mitigate the injury done by birds that feed on Hymenoptera. The facts at hand show that, excluding ants (which are in no way concerned with parasites), Hymenoptera compose not more than from 3 to 5 percent of bird food in general. Of the insects composing this percentage, according to our identifications, nonparasitic forms outnumber the parasites in the proportion of about 4 to 1. Hence at most not more than 1 percent of the food consumed by all the members of our avifauna consists of parasitic Hymenoptera, taken as free-moving forms.

Proceeding now to the main point at issue, whether great numbers of parasites in the egg or larval state are eaten by birds along with the usual prey, the following statements can be made. The parasites in insect eggs (which include very many of the large superfamily Proctotrypoidea, and some others) are absolutely safe from the majority of birds, only the smaller titmice, warblers, etc., searching much for eggs. Parasites also in the cocoons and chrysalids are comparatively secure, as only few birds consume these objects. The parasites of all minute insects, like egg parasites, are exempt from danger, except from a certain contingent of the smaller birds. The parasites living upon medium-sized caterpillars, beetle larvæ, and adult insects, however, run considerable risk of becoming bird food. But even members of this group are in a measure favored, since a good proportion of the caterpillars or other insects they infest are not likely to be eaten by birds, both because they are usually discolored or otherwise abnormal in appearance and because often they are inactive, and hence escape attention. It should be stated, however, that freshly parasitized individuals are of normal appearance, and whether or not they are recognized by birds, it is certain that in the stomach such caterpillars can not be distinguished from the uninfested.

However, it is certain that, in spite of this difficulty of recognizing recently parasitized larvæ, a well-defined tendency on the part of birds to avoid these doomed insects is shown by the wholly insignificant number found in which parasitism is evident. Only the one parasitized caterpillar mentioned above, and one other eaten by a hawk, have been found in more than 40,000 stomachs examined by the Biological Survey. Hence it would seem that serious diminution in the ranks of parasites is much more logically explained by some other cause, such as the well-known pernicious activities of certain hyperparasites, than by the attacks of predaceous foes. The following extract[a] from "A Study of the Hymenopterous Parasites of the American Tent Caterpillar," by W. F. Fiske, serves to show the possibilities of this hyperparasitical activity.

> In 1896 it [the tent caterpillar] was exceedingly common, so much so as to attract attention all over the State, and it was consequently assumed that its parasites would also have increased to such an extent as to be a considerable factor in bringing about a more normal condition in 1897. But strangely enough this reasoning was found to be diametrically opposite to the facts of the case. In 1896 a great many caterpillars were destroyed by *Limneria fugitiva* [a parasite], and numbers of the characteristic cocoons of this species were collected and bred at this station. These proved in their turn to be almost entirely the prey of *Pimpla inquisitor* [a hyperparasite], and the breeding cages in which the cocoons were confined becoming filled with the adults of the hyperparasite, it was mentioned in the report of the year, and given credit for the destruction of large numbers of tent caterpillars. Thus it was the *Limneria* which proved to be the real victim, and as its cocoons were rare the next year the primary host, *Clisiocampa americana* [the tent caterpillar], was indirectly but decidedly the gainer.
>
> As one season's observations succeeded another's this case from being an exception, as was at first thought, was found to be more nearly the rule. The comparative abundance of the tent caterpillars varied greatly, it is true, but this was obviously due to other and distinct causes than this under discussion, and only a certain percentage, varying considerably from one colony to another, or to a less degree between different localities, fell a prey to the hymenopterous parasites. The parasites as a body were found to exact a certain tithe of blood, so to speak, and this being obtained would proceed to fight over its possession, passing it from one to another, from parasite to hyperparasite, until often, perhaps, there would be little more than enough left of a single large caterpillar than that sufficient to support a single small Chalcid.

It is evident from these statements that we need look no further for the enemies which so check the useful services of parasites.

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[a] Tech. Bull. 6, N. H. Agr. Exp. Sta., 1903, pp. 185–186.

Comparisons of the usefulness of parasitic insects and of predaceous species, both insects and birds, have been made to the disparagement of the latter class and in consequence the benefits conferred by parasites have sometimes been exaggerated. But in weighing the importance of these statements it should not be forgotten that essentially parasites are dependents. It is farthest from their object to exterminate their hosts, even in a limited area. This result, which in most cases means disaster to the parasite, is, on the other hand, of but little moment to predaceous insects or birds. The latter always have a wide range of prey and even if one food supply is exhausted usually there are others at hand. The best evidence that predaceous foes of insects are worthy of as high consideration as parasitic ones is afforded by the instance of the extermination, successively, by the ladybird, *Novius cardinalis*, of the cottony cushion scale in California, of the fluted scale in South Africa, and of a congeneric scale insect in the gardens of Alexandria, Egypt. These are absolutely the most important services in destroying insects ever rendered to man and were accomplished by a predaceous enemy which is chargeable with the same lack of nice discrimination with respect to parasites attributed to birds.

However, there is no necessity for belittling the services of either of the two great classes of pest destroyers. Both consume a certain proportion of insects directly injurious to man and it is more than likely that either would be hindered rather than helped by the absence of the other. Everything, indeed, points to the conclusion that from the standpoint of man's welfare the loss of either class would irreparably disturb the balance. What has been said by a noted entomologist concerning parasites, namely, that the presence of both parasites and hosts, continuing through thousands of years to the present, implies that an equilibrium is maintained enabling each to live, is just as true of predaceous enemies, both in relation to parasites and to their common prey. There can be no doubt that, even under the greatly changed conditions induced by man, the interactions of these classes tend directly toward the establishment and maintenance of a balance. It is probable that this balance can be secured at a lower level in regard to number of individuals only by direct reduction of the injurious species by man, coupled with the best possible protection of both their predatory and parasitic enemies.

GENERAL CONCLUSION.

With respect to food habits it appears that the grosbeaks form a group apart from the majority of the finch family, to which they belong. The members of this group are by no means the extreme vegetarians they are commonly supposed to be, since on the average they consume about 25 per cent of animal food. The grosbeaks, however, are even less exclusively vegetarian than others of the family and nearly half their food is animal. Moreover, the constituents of the animal dietaries of the two groups differ considerably. Nearly all finches hitherto examined have been found to avoid hairy caterpillars, but the grosbeaks eat them eagerly. True bugs generally are neglected by the smaller members of the sparrow tribe, while the grosbeaks consume on an average 7.25 percent of these strongly flavored insects. Further, while caged and hungry individuals of some of the smaller sparrows refused both the Colorado and three-lined potato beetles, cucumber and ladybird beetles, and also stinkbugs of the genus *Euschistus*, each of these insects is captured in the open by one or more, if not all, of the grosbeaks. In fact, the so-called protected fireflies, leaf beetles, and ladybirds, as also hairy caterpillars and the adaptively colored or distasteful bugs and scale insects, seem poorly defended, for all of them serve as grist for the grosbeak mill. A difference between the vegetable dietaries of the grosbeaks and other sparrows is also worthy of notice. Weed seeds form half of the annual food of the latter group, while only one of the grosbeaks devours so large a proportion, the others consuming an average of about 18 percent.

To the grosbeaks in particular, as to the sparrow family as a whole, general traits have been ascribed as characteristic which investigation fails to substantiate. For instance, the grosbeaks are found to have no special predilection for buds, notwithstanding popular opinion to the contrary. Then, too, it is generally considered that the massive grosbeak bill is especially designed to crack hard fruits and seeds, and it would appear certain that in some way it is related to peculiarities of food. Yet the smaller sparrows and the cowbirds, with much weaker bills, break all sorts of seeds as readily as the cardinal. Indeed, the food habits of the grosbeaks, as revealed by the present investigation, offer no clue to the origin of the form of bill. Its great crushing capacity appears to be utilized only on rare occasions, one cardinal, for instance, out of 500 eating a hickory nut. Practically all the food eaten by grosbeaks seemingly could be manipulated just as readily by birds with comparatively slender beaks. It is true that the curiously curved beak of the parrot-bill may be useful in securing the much relished seeds of bur grass (*Cenchrus*), but the same kind of seeds is eaten also by the straight-beaked cardinal. No doubt there is an intimate connection between the size and form and the function of the grosbeak bill, but for the key apparently we must look to past conditions of environment, for its extraordinary size and shape appear to answer no present needs.

Notwithstanding also the general similarity of bills, as well as of other points of structure, the five grosbeaks differ considerably in food habits. This divergence is beneficial to the birds, no doubt, when they occupy the same general territory, since it keeps them apart when foraging, each thus securing enough food without competing too strenuously with its neighbor. It is of great value also to man, because the birds exact tribute from the whole field of his insect enemies.

As would be expected, the cardinal and gray grosbeaks have somewhat similar tastes. They rank highest of the group as seed eaters; they consume little grain, capture a very small number of Hymenoptera, and relish weevils best among beetles and grasshoppers among other insects. The cardinal alone is very fond of wild fruit, the place of this item in the regimen of the gray grosbeak being filled by a corresponding quantity of weed seed. The rose-breasted and black-headed grosbeaks also have similar preferences, each manifesting indifference toward grasshoppers but each relishing Hymenoptera and true bugs. Fruit is held in about the same estimation by the two birds, though the blackhead is much more injurious to cultivated varieties. Both it and the rosebreast make a specialty of leaf-beetles, each selecting a single species as one of its most favored foods. The blackhead pays slight attention to grain and weed seed, but feeds ravenously on scale insects; and the rosebreast, while by no means neglecting scales, feeds more extensively on cereals and seeds. The blue grosbeak is peculiar in three respects: It shows a very strong liking for grasshoppers, for lamellicorn beetles, and a maximum avidity for grain; and it is like the gray grosbeak in almost totally neglecting fruit.

Preferences such as the above explain why one species attacks particular crops which the others never touch. Thus, from the standpoint of the fruit grower the blue grosbeak is entirely beneficial, but the grain grower sometimes has reason to execrate this species, while to him, the blackhead, which injures the fruit of his neighbor, seems innocent. But as has been shown in preceding pages the beneficial qualities predominate in both birds and "it is well to remember," as is wisely said by Wilson Flagg,[a] "that nature does not grant us a benefit without taking some compensation. We must be content to pay for the services of our useful birds by allowing them as a perquisite a certain portion of the fruits of our soil. We must pay the crow and blackbird in corn, and the robin and the cedar bird in cherries; and if it be objected that the robin tax falls disproportionately upon the fruit growers, so, on the other hand, the blackbird tax falls disproportionately upon the farmer and the corn grower. These evils, except as they can be prevented by watchfulness and ingenious contrivances that do not harm the bird, must be patiently endured for the common good."

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[a] Ann. Rep. Mass. Bd. Agr. (1861), 1862, Appendix, p. 76.

Looking beyond the confines of the individual orchard or grain field, it is apparent that the grosbeaks make small demands either on our patience or endurance. The brief season of crop pilfering is a comparatively insignificant part of the otherwise beneficial yearly life of the grosbeaks, a fact sometimes lost sight of. The importance of birds as checks upon the insect enemies of agriculture, and the fact that they are among the most valuable assets of the farm, are too well known to require proof. No one should be so blinded to his own best interests by a sense of present injury as to destroy by wholesale creatures which by every intent and provision of nature are among his best friends. The destruction of the most grievous pests known to us by birds give them a value comparable in degree, if not in kind, with that of some of the useful domestic animals, and when they are caught in mischief, they should be dealt with on the same principle as domestic stock, that is, with a view of preserving them for future service. Farm animals are not destroyed when they commit devastations; measures are taken to protect the crops from future raids by strengthening weak and broken fences. Similarly, crops should be protected against the raids of birds, and experiments have demonstrated that bird netting, tarred seed, and decoy fruit trees, among other things, may successfully be employed to this end, while at the same time the birds are preserved to turn their energies to better account in destroying insect pests.

No group of birds better deserves to be treated in this fair and practical way than the grosbeaks. The details of their useful habits, as given in the preceding pages, need not be repeated, but since a final estimate of the value of the group depends upon the exact nature of the food of its several members and their relation to agricultural interests, it is proper to restate general conclusions: The five grosbeaks studied consume on the average nine times more weed seed than grain and fruit. Moreover, they devour nineteen times more injurious than useful insects. Consequently, since their subsistence is about half animal and half vegetable, their food habits are about fourteen times more beneficial than injurious. It has been shown, furthermore, that they attack many destructive insects, even specializing on some of the greatest pests. The grosbeaks, therefore, making due allowance for the injury they do, are of great economic value, and it is evident that the farmer will derive great advantage by preserving them.

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BIOLOGICAL SURVEY—BULLETIN No. 33

C. HART MERRIAM, *Chief*

THE BROWN RAT IN THE UNITED STATES

BY

DAVID E. LANTZ
ASSISTANT, BIOLOGICAL SURVEY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

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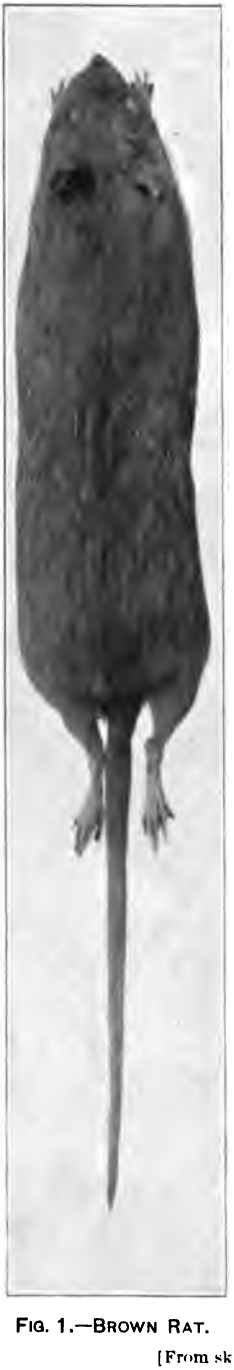

FIG. 1.—BROWN RAT.

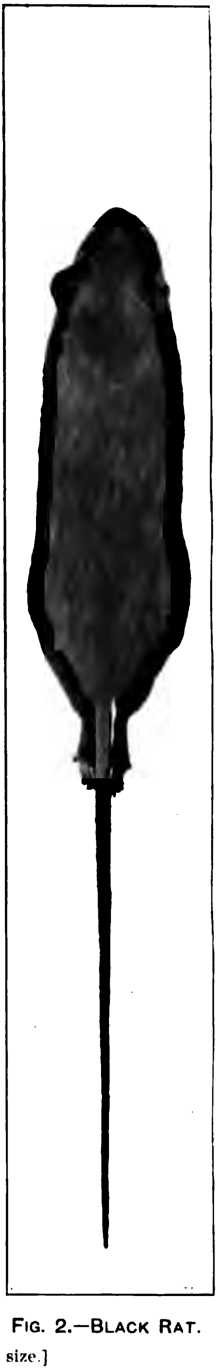

FIG. 2.—BLACK RAT.

[From skins. One-third natural size.]

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., January 28, 1909.

Sir: I have the honor to transmit herewith a report on the Brown Rat in the United States, by Prof. David E. Lantz, and to recommend its publication as Bulletin No. 33 of the Biological Survey.

The rat is believed to be the worst mammalian pest known to man. Not only does it damage property to the extent of many millions of dollars annually, but to this pecuniary loss must be added the still greater harm it inflicts by the dissemination of the dreaded plague and other diseases. Boards of health of many maritime cities in this and other countries are now engaged in an active campaign against rats, but thus far without very gratifying success. In Japan, where the Government is awake to the seriousness of existing conditions, the number of rats destroyed annually, according to Professor Kitasato, varies "from several hundred thousand to a million. Nevertheless at the present day no appreciable diminution in the number of rodents can be noticed. Reproduction keeps pace with destruction, so that we are at a loss to know how to proceed." In order to secure effective cooperation it is important to impress on the public the need of concerted and sustained effort, and particularly the necessity of depriving these noxious animals of the lavish supply of food and shelter now unwittingly furnished them. In this connection it is believed that the present bulletin will prove helpful.

Respectfully,

C. Hart Merriam,
Chief Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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THE BROWN RAT IN THE UNITED STATES.

INTRODUCTION.

The rat is the worst mammalian pest known to man. Its depredations throughout the world result in losses amounting to hundreds of millions of dollars annually. But these losses, great as they are, are of less importance than the fact that rats carry from house to house and from seaport to seaport the germs of the dreaded plague.

Once occupying only a comparatively small part of the Old World, through the spread of commerce the brown rat has been furnished free transportation to the uttermost parts of the earth, while its fecundity, cunning, and adaptability to almost every kind of environment have enabled it to flourish and multiply wherever it has secured a foothold.

Man s antipathy to the rat is not new. For centuries the animal has been banned, and human ingenuity has been taxed to the utmost to suppress it. Innumerable devices in the way of traps, poisons, gases, and, more recently, cultures supposed to spread fatal diseases have been resorted to. Nevertheless, the pest continues to prosper, and its numbers and destructiveness keep pace with the advance of civilization. Everywhere the history of the contest is the same. Though thousands are killed, the relief is only temporary, and other thousands soon replace the slain. Therefore, if conducted along the old lines, the war promises to be never-ending.

The futility of past efforts and the lack of permanent results indicate that the real cure for the rat evil in cities, especially seaports, lies in preventive rather than curative methods. The extraordinary success that has attended the rat's struggle for existence is to be explained largely by the abundance of food and shelter furnished by man. Preventive measures should be directed to withholding these advantages. The curtailing of food is less important in its effect on the present rat population than in its certain result in lessening reproduction. Abundance of food means many young in a litter and many litters in a year; a restricted supply means fewer young and fewer litters. The most important steps, therefore, toward the suppression of the rat are:

(1) *The enactment and strict enforcement of municipal ordinances providing for the disposal of garbage and the protection of food supplies.*— Every effort should be made to instruct the public as to the necessity

for care in the disposition of refuse and the protection of food materials. Tightly closed garbage cans frequently emptied will go far toward limiting the food available for rats. Grain bins in private and public stables, now affording food and harborage for thousands of rats, and public markets and feed, provision, and grocery stores, notoriously lacking in protection against rats, should have their contents safeguarded from these animals.

(2) *The rat-proof construction of dwellings and public buildings.*—The advantages of cement in the cellars and foundations of public and private buildings are now so well understood that the rat-proofing of buildings by cement construction and other necessary measures should be no longer left to individual inclination and judgment, but should be incorporated in building regulations, and these strictly enforced. The additional expense, compared with the advantages, is trivial.

The above measures are of first importance, but they will not entirely solve the problem of rat repression. The destruction of rats, wherever they are numerous, is very important and at times absolutely necessary in the interests of public health. Hence in the following pages are given the best methods known for destroying rats, many of which have been developed by experiments and practical trials. Such methods, however, are fallible and at best inferior to preventive measures. The cutting off of the chief sources of food supply will limit the increase of the pests to a minimum, while the general construction of rat-proof buildings will deprive them of shelter and breeding places. The two measures will thus strike at the very root of the evil, and if supplemented when necessary by a vigorous campaign of destruction will prove vastly more effective, much less expensive, and productive of far more enduring results than any measures hitherto attempted.

DESTRUCTIVENESS OF THE BROWN RAT.

At the head of the rat family for destructiveness stands the brown rat (*Mus norvegicus*), called also gray rat, house rat, barn rat, wharf rat, and Norway rat. (Pl. I, fig. 1.) Like all members of the genus *Mus* found in America, the animal is not a native, but is an immigrant from the Old World. In spite of constant warfare waged against it, the brown rat has steadily increased in numbers, and has spread to almost all parts of the country reached by railways or by steamship lines. Accidentally brought to our shores after the middle of the eighteenth century, in most places it has driven out or exterminated its less robust relative, the black rat. The dominance of the brown rat is probably due to its superior strength and ferocity, its greater fecundity, its peculiar adaptability to various environments, and its more pronounced burrowing habit.

The present bulletin is intended to acquaint the public with the habits of the brown rat,[a] the nature and extent of the losses inflicted by it, and the best available methods of fighting it. It is believed that such knowledge will result in more persistent attempts, through cooperation and individual effort, to exterminate the pest, or at least permanently to reduce its numbers.

DISTRIBUTION OF THE GENUS MUS IN AMERICA.

True rats and mice belong to the Old World genus *Mus*, of which nearly 300 species have been described. Of these about seven-eighths are properly to be classed as rats and the remaining one-eighth as mice. Among all the species of *Mus* four have developed the ability to adapt themselves to such a variety of conditions as to climate and food that, carried on ships, they have established themselves in many parts of the world. These four are the only species of *Mus* that have become acclimatized in America.

The common house mouse (*Mus musculus*) found its way to America soon after the first settlement by Europeans. It is now distributed in all settled parts of North and South America, but in the extreme north it does not always survive the winters, and is therefore scarce.

The black rat (*Mus rattus*) (Pl. I, fig. 2) was carried to South and Middle America about three and a half centuries ago. The time of its arrival in the English colonies of North America is uncertain, but it was well established in the settled portions by the beginning of the eighteenth century. After the arrival of the brown rat, it began to decrease in numbers and gradually to disappear until it has become rare in most parts of the United States and Canada. It is now found in scattered colonies mostly east of the Mississippi Valley and on certain islands along the coast on both sides of the continent. It is occasionally observed in most of our seaports. The Biological Survey has specimens from Massachusetts, New Hampshire, Georgia, Florida, Alabama, California, and Washington, as well as from Mexico, Honduras, Nicaragua, and Hawaii. Also there are authentic records of its recent occurrence in Newfoundland, Quebec, Nova Scotia, New York, North Carolina, Tennessee, West Virginia, and Mississippi. In parts of South and Middle America the black rat has been more persistent and is still abundant.

The roof, or Alexandrian, rat (*Mus alexandrinus*) is similar to the black rat in form and habits, though not in color. Little is known of its history, but it is supposed to be a native of Egypt, where it is still abundant. It is almost as remarkable as the brown rat for its wandering propensities, and it is probably quite as common on seagoing ships. It has established itself in seaports in many parts of the world, mainly in warm climates, and is common near the coast in southern parts of the United States. The Biological Survey has specimens from North Carolina, Georgia, Florida, Alabama, Mississippi, Texas, Arizona, and California. In the last-named State it is abundant in the Sacramento Valley. The species is known from Lake Drummond, Va., and from Cuba, the Bermudas, Trinidad, San Domingo, Costa Rica, Nicaragua, Mexico, and Hawaii. It occurs also in many parts of South America, where it is often the dominant species.

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[a] While this paper deals primarily with the brown rat, some of the illustrative facts quoted throughout the following pages refer to the black rat (*Mus rattus*) and to the roof rat (*Mus alexandrinus*). The habits of the three species differ so little that the methods given for combating them apply to all. In some of the discussions of losses caused by rats it has not been practicable to exclude those due to the common house mouse (*Mus musculus*).

In most parts of the United States the rat common about houses and barns is the brown rat. It is larger and more robust than either the black rat or the roof rat, and differs from them considerably in habits. Unlike them, it almost always burrows in the ground under buildings and in loose soil along hedges and river banks. This habit affords better protection from enemies and, combined with the animal's greater ferocity, has enabled it to supplant the other species in temperate latitudes; but in the warmer parts of America it has not always been able to do this, and the roof rat appears to be most numerous in many localities.[a] The house mouse escapes the brown rat by taking refuge in crevices and other retreats too small for its foe to enter.

The brown rat inhabits most of the thickly populated parts of America. North of Panama it occurs from the Isthmus to the Yukon Valley and to Greenland, except on the interior table-lands and perhaps in a few sections of the South. Between the Rocky Mountains and the Sierra it is confined almost entirely to towns along the railroads. The Biological Survey is without records of its presence in Nevada, Utah, Wyoming, or Idaho. The ability of the species to withstand extreme cold is proved by the fact that it flourished in latitude 78° 37′ north, on board the ship *Advance* of Doctor Kane's second Grinnell expedition during the two winters of icebound experience. It has been able to adapt itself also to the continuous low temperatures of cold-storage plants in many of our cities.

HISTORY OF THE BROWN RAT.

The early history of the brown rat is practically unknown. The species is generally supposed to be of Asiatic origin, but we have no positive knowledge as to its native country. Various modern writers have asserted that it came originally from Persia or India. But Mr.

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[a] In the principal Asiatic seaports the brown rat is said to be often found closely associated with the other two forms.

W. T. Blanford states that the species is at present unknown in Persia, and that, as concerns India, the black rat is the generally distributed species, while the brown rat is found only along the coast and the navigable rivers.[a] This statement seems to imply that the latter is a comparatively recent immigrant into India. Early Greek and Roman writers make no mention of the rat, but it is possible that they knew the animal and included it in their references to mice.

As regards the time of the brown rat's introduction into Europe, we have two known facts. The species reached England from some eastern port about 1728 or 1729, and a little earlier it crossed the Russian frontier from Asia. Pallas, the naturalist and traveler, states that it first reached Europe from the east by way of the Volga, which river it crossed in 1727, and soon afterwards spread over the greater part of Russia.[b] In view of the statement of Blanford, already referred to, it is highly probable that previous to this migration the Asiatic home of the species was northward rather than southward of the mountain barriers of northern India. This view has been advanced by several naturalists and is further strengthened by the fact that the animal appears to flourish better in a temperate than in a tropical climate.

The brown rat is said to have first appeared in Paris in 1750. It was brought to the United States, probably from England, about the beginning of the Revolution, 1775. According to Audubon, it was unknown on the Pacific coast of the United States in 1851, although its introduction there must have occurred soon afterwards.

GENERAL DESCRIPTION.

The brown rat differs from the other two species in America in larger size, shorter head, more obtuse muzzle, smaller ears, and relatively shorter tail. The general color is grayish brown above and whitish below. The overhairs of the upper parts have black tips. The tail is usually shorter than the head and body combined, while in the other two species it is generally longer.

The black rat is usually of a sooty or plumbeous black color, paler on the underparts; while the roof rat is slightly grayer than the brown rat above and yellowish white on the feet and belly.

The skull of the brown rat shows well-marked differences from those of the other two species, but the skulls of the roof rat and the black rat are not readily distinguished from each other. Many zoologists regard the black rat as only a geographic race of the roof rat. The two forms interbreed freely.

The tame white rats of the bird stores are said to be mostly of the *Mus rattus* type; but albino and spotted specimens of the brown rat are not uncommon. The only albino rats in the collections of the National Museum and the Biological Survey are *Mus norvegicus*. Black, or melanistic, forms also of the brown rat are known.

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[a] Fauna of British India, Mammals, p. 409, 1891.

[b] Zoographica Rosso-Asiatica, Vol. I, p. 165, 1831.

The average measurements of adult specimens of the brown rat in the Biological Survey collections are as follows: Total length 415 mm. (16.4 inches); tail 192 mm. (7.1 inches); hind foot 43 mm. (1.7 inches). This rat sometimes attains a total length of 19 to 20 inches and has been known to weigh 24 to 28 ounces. The average weight of an adult is less than a pound.

ABUNDANCE OF RATS.

Few persons realize the vast numbers of rats that may inhabit a very small area. In cities, particularly, the animals swarm along river fronts and wharfs, as well as in sewers, stables, warehouses, markets, and other places where food is abundant. It is only when some of these harbors are demolished that the real numbers of the rats are discovered.

The number of rats that may harbor on an ordinary farm is astounding. In 1901 an estate of 2,000 acres near Chichester, England, was badly infested with the pests. They were systematically destroyed by traps, poisons, and ferrets. The total number destroyed under the personal supervision of the owner was 31,981; while it was estimated that tenants at the thrashing had killed fully 5,000 more. Even then the property was by no means free from rats.[a]

During the plague of rats on the island of Jamaica in 1833, the number killed on a single plantation in a year was 38,000. The injury to sugar cane on the island by the animals was at that time estimated at half a million dollars a year.[b]

An idea of the immense number of rats that may infest a country may be obtained from the report of the Indian Famine Commission presented to the English Parliament in 1881. An extraordinary plague of the animals infested the southern Deccan and Mahratta districts of India. The autumn crop of 1878 and the spring crop of 1879 were both below the average, and a great portion of the product was destroyed by rats. Rewards were paid for the destruction of the pests, and over 12,000,000 were killed.[c] While they were mostly of the black species, the illustration of abundance applies just as well to the brown rat, which is even more prolific.

HABITS OF RATS.

Close observation of the habits of wild rodents, especially of those chiefly nocturnal, is difficult. It is not surprising, therefore, that information on the life history of an animal so common as the brown rat should be meager, nor that diverse opinions about its breeding should be current. When wild rats are kept in confinement, they rarely breed, and the conclusions as to their breeding have been inferred from observations of domesticated white rats.

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[a] The Field (London), vol. 100, p. 545, 1902.

[b] New England Farmer, vol. 12, p. 315, 1834.

[c] British Medical Journal, September 16, 1905, p. 623.

BREEDING.

Observations show that climate and food supply greatly affect the rate of multiplication of rodents. The rat is no exception. It increases most rapidly in a moderately warm climate and with an abundant supply of food. Extremes of heat and cold retard its multiplication, decreasing both the number of litters produced in a year and the number of young brought forth at a time.

As already stated, the brown rat is more prolific than either of the two other species mentioned. The female brown rat generally has 12 mammæ—3 pairs of pectoral and 3 pairs of inguinal, although these numbers are by no means constant. The black rat and the roof rat have but 10 mammæ—2 pairs of pectoral and 3 pairs of inguinal, with but little tendency to vary. Records of actual observations confirm the deductions to be drawn from the above facts. At Bombay, India, during the recent investigations of the India Plague Commission, 12,000 rats were trapped and examined. The average number of embryos observed in pregnant brown rats was 8.1; the highest number, 14. The average for the black rat was 5.2; the largest number, 9.[a]

In temperate latitudes the average litter of the brown rat is probably considerably greater than the number above given. Instances of very large litters observed in England have been recorded in the Field (London). In two cases 22 and 23 young, respectively, were found in one nest, and in two other instances 17 and 19 were found in gravid females. A reliable observer residing in Washington, D. C., found 19 young rats in a single nest. The writer, on March 25, 1908, caught 6 rats in one trap, 3 of which were pregnant females, containing 10, 11, and 13 embryos, respectively. While we have hardly enough data on which to base definite conclusions for this latitude, we may safely conclude that the average litter is not less than 10.

The number of litters of young produced in a year by the brown rat is not definitely known, and probably varies with local conditions. Dehne's observations on white rats showed that in one instance an interval of only 71 days intervened between two litters from the same rat. A young female of the first litter gave birth to 6 young when she was only 103 days old.[b] Frank T. Buckland in his Curiosities of Natural History, relates that a white rat which he kept in captivity gave birth to 11 young when only eight weeks old. As gestation in rats occupies three weeks, this animal must have bred when only five weeks old. Kolazy records instances of but 25 days between successive litters of well fed albino rats.[a]

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[a] Etiology and Epidemiology of Plague, p. 9. Calcutta, 1908.

[b] Brehm's Thierleben: Säugethiere, Vol. II, p. 353, 1877.

The known facts concerning the reproduction of the brown rat in temperate latitudes may be briefly stated as follows: The animals breed from three to five times a year, each time bringing forth from 6 to 20 young. After a gestation period of 21 days, the female gives birth to her young in nests in underground burrows or under floors, stacks, lumber, wood piles, or other shelter. The young are blind and naked when born, but grow rapidly, and the females are capable of breeding when less than three months old.

If we assume that the animals breed three times a year and that the average litter is ten, and suppose that a pair and their progeny breed uninterruptedly at this rate for three years, with no deaths, the result would be as follows:

Theoretical results of three years' (nine generations) uninterrupted breeding of a pair of brown rats.

	Generation.								
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Number of pairs breeding	1	6	36	216	1,296	7,776	46,656	279,936	1,679,616
Number of young produced	10	60	360	2,160	12,960	77,760	466,560	2,799,360	16,796,160
Total number of individuals	12	72	432	2,592	15,552	93,312	559,872	3,359,232	20,155,392

Of course, such results never occur in nature. Apparently not nearly half the rats born are females; at least, among mature rats the males greatly predominate. Then, too, the life of young rats, as well as that of the old, is a continuous struggle for existence. Disease, the elements, natural enemies, the devices and cunning of man, and even cannibalism are continually at work to reduce their numbers.

MIGRATIONS AND INVASIONS.

Migrations of rats have often been recorded. Pallas narrates that in the autumn of 1727 the brown rat arrived at Astrakhan in southern Russia from the east in such numbers and in so short a time that nothing could be done to oppose them. They crossed the Volga in large troops. The cause of the migration was attributed to an earthquake; but since similar movements of this species often occur unattended by earth disturbance, it is probable that only the food problem was involved in the migration which first brought the brown rat to Europe.

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[a] Verh. Zool. Botan. Gesel., Wien, pp. 731–734, 1871.

In nearly all countries a seasonal movement of rats from houses and barns to the open fields occurs in spring, and the return movement takes place as cold weather approaches. The movement is noticeable even in large cities.

But more general movements of rats often occur. In 1903 a multitude of migrating rats spread over several counties of western Illinois. They were noticed especially in Mercer and Rock Island counties. For several years prior to this invasion no abnormal numbers were seen, and their coming was remarkably sudden. An eyewitness to the phenomenon informed the writer that as he was returning to his home by moonlight he heard a general rustling in the field near by, and soon a vast army of rats crossed the road in front of him, all going in one direction. The mass stretched away as far as could be seen in the dim light. These animals remained on the farms and in the villages of the surrounding country, and during the winter and summer of 1904 were a veritable plague. A local newspaper stated that between March 20 and April 20, 1904, Mr. F. U. Montgomery of Preemption, Mercer County, killed 3,435 rats on his farm. He caught most of them in traps.[a]

In 1877 a similar migration occurred into parts of Saline and Lafayette counties, Mo.;[b] and in 1904, one came under the writer's observation in Kansas River valley. This valley for the most part was flooded by the great freshet of June, 1903, and for about ten days was covered with several feet of water. It is certain that most of the rats in the valley perished in this flood. In the fall of 1903 much of the district was visited by hordes of rats, which remained during the winter, and by the following spring had so increased in numbers that serious losses of grain and poultry resulted.

No doubt the majority of the so-called migrations of rodents are in reality instances of unusual reproduction or of enforced migration owing to lack of food. In England a general movement of rats inland from the coast occurs every October. This is closely connected with the closing of the herring season. During the fishing, the rodents swarm to the coast, attracted by the offal left from cleaning the herring; and when this food supply fails, they hasten back to the farms and villages.

In South America periodic plagues of rats have taken place in Parana, Brazil, at intervals of about thirty years, and in Chile at intervals of from fifteen to twenty-five years. These plagues in the cultivated lands follow the ripening and decay of the dominant species of bamboo in each country. The ripening of the seed furnishes for two or more years a favorite food for rats in the forests, where the animals multiply greatly; when this food fails they are forced to the cultivated districts for subsistence. In 1878 almost the entire crops of corn, rice, and mandioca in the State of Parana were destroyed by rats, causing a serious famine.[a]

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[a] Moline (Ill.) Evening Mail, April 25, 1904.

[b] Forest and Stream, vol. 8, p. 380, July 12, 1877.

An invasion of black rats (*Mus rattus*) in the Bermuda Islands occurred about the year 1615. In a space of two years they had increased so alarmingly that none of the islands were free from them. The rodents devoured everything which came in their way—fruit, plants, and even trees—so that for two years the people were destitute of bread. A law was passed requiring every man in the islands to set 12 traps. In spite of all efforts, the animals increased, until they finally disappeared with a suddenness which could have resulted only from a pestilence.[b]

FOOD OF RATS.

The brown rat is practically omnivorous. The statement applies as well to the black rat and the roof rat. Their bill of fare includes seeds and grains of all kinds, flour, meal, and food products made from them; fruits and garden vegetables; mushrooms; bark of growing trees; bulbs, roots, stems, leaves, and flowers of herbaceous plants; eggs, chicks, ducklings, young pigeons, and young rabbits; milk, butter, and cheese; fresh meat and carrion; mice, rats, fish, frogs, and mussels. This great variety of food explains the ease with which rats adapt themselves to almost every environment.

Experiments show that the average quantity of grain consumed by a full-grown rat is fully 2 ounces daily. A half-grown rat eats about as much as an adult. Fed on grain, a rat eats 45 to 50 pounds a year, worth about 60 cents if wheat, or $1.80 if oatmeal. Fed on beefsteaks worth 25 cents a pound, or on young chicks or squabs with a much higher prospective value, the cost of maintaining a rat is proportionately increased. Granted that more than half the food of our rats is waste, the average cost of keeping one rat is still upward of 25 cents a year.

If an accurate census of the rats of the United States were possible, a reasonably correct calculation of the minimum cost of feeding them could be made from the above data. If the number of rats supported by the people throughout the United States were equal to the number of domestic animals on the farms—horses, cattle, sheep, and hogs—the minimum cost of feeding them on grain would be upward of $100,000,000 a year. To some such enormous total every farmer, and indeed every householder who has rats upon his premises, contributes a share.

But, as will be shown later, the actual depredations of rats are by no means confined to what they eat. They destroy fully as much grain as they consume, and they pollute and render unfit for human consumption a much larger proportion of all other food materials that they attack. In addition, the damage they do to property of other kinds is often as great as that done to food supplies.

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[a] Nature, vol. 20, p. 65, 1879.

[b] Popular Science Monthly, vol. 12, p. 376, June, 1878.

DAMAGE BY RATS.

But few attempts have been made to collect statistics of damage done by noxious animals in America. The reported items of loss are so scattered and fragmentary that no accurate estimate of their amount is possible. In some parts of Europe, where agricultural holdings are small and minute economies prevail, such statistics are sometimes collected. Thus in Russia returns of the losses from predatory Carnivora in the various provinces are published annually.

A few estimates of the amount of losses from rats in foreign countries have been published. In Denmark they have been reported as amounting to 15,000,000 francs ($3,000,000) yearly.[a] In France in 1904 the total losses from rats and mice were estimated at 200,000,000 francs (nearly $40,000,000).[b] The German Ministry of Agriculture, in a circular addressed to various subordinate chambers of agriculture, states that the people of Germany suffer an annual loss through the agency of the rat of at least 200,000,000 marks ($50,000,000). Sir James Crichton-Browne, of the English Incorporated Society for the Destruction of Vermin, says that the damage done by the rat in Great Britain and Ireland "in its rural activities, to say nothing of what it does in towns and in connection with shipping, is £15,000,000 (about $73,000,000) per annum."[c]

The principal ways in which rats inflict losses in the United States are discussed under the various subheadings below.

GRAINS.

Cultivated grains may be regarded as the favorite food of rats. The animals dig the seed from the ground as soon as sown, eat the tender sprouts when they appear, and later feast upon the maturing crop. After harvest they attack grain in shock, stack, and mow, and when thrashing is over, in crib, granary, elevator, mill, and warehouse. The toll thus taken varies with the numbers of the rodents, and in some places amounts to a considerable percentage of the crop. In exceptional cases entire crops have been ruined by rats.

Indian corn.—On the whole this crop suffers greater injury from rats than any other in the United States. Besides depredations on newly sown seed, the animals attack the growing grain when in the milk stage. They climb the upright stalks and often strip the cobs clean of grain. The writer has seen whole fields of corn so destroyed, and in many cases has observed parts of fields amounting to several acres practically ruined. A writer in the American Agriculturist reported an instance in which rats destroyed three-fourths of the corn on 13 acres of land.[a] In 1905 a large portion of the crop grown on the Potomac flats, near Washington, was destroyed by rats (Plate II). The crops for 1906 and 1907 were saved by the use of traps and poisons.

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[a] Dr. Adrian Loir in Jour. d'Agri. Tropicale, vol. 3, p. 369, December 31, 1903.

[b] Jour. Board of Agri., Great Britain, vol. 2, p. 50, 1904.

[c] Jour. Inc. Soc. Dest. Vermin, vol. 1, p. 74, October, 1908.

Corn in the field, if left standing long in the shock, is liable to injury from rats. A pair of the animals will soon ruin an entire shock, destroying both grain and fodder. Such damage is sure to take place if the corn is near hedgerows, embankments, drains, or other harbors where rats are abundant; but sometimes the shocks themselves furnish shelter for the animals.

Rats often damage corn in cribs. Too frequently these receptacles for grain are built close to the ground, and rats live under the floor. They often perforate the wooden barrier and thereafter have free access to the grain. They shell the corn, eating the softer part of the kernel and wasting much more than they consume. They carry the grain to subterranean burrows and bring up into the crib moist soil, which induces mold in the corn and leaves much unfit for market or for feeding stock. A correspondent in Arkansas once wrote to the secretary of the American Institute, stating that fully half his corn was destroyed by rats after it was placed in the crib.[b]

A farmer living near Grand River, Iowa, relates the following experience:

"We had about 2,000 bushels of corn in 3 cribs to which rats ran, and they ate and destroyed about one-fourth of the corn. Much of it was too dirty to put through the grinder until it had been cleaned an ear at a time. All the time we were poisoning and trapping the rats. We killed as high as 300 rats in two days and could hardly miss them. They destroyed more than enough corn to pay taxes on 400 acres of land." [c]

The foregoing are extreme cases, but too often farmers lose a considerable portion of the crop by rat depredations. A little forethought and care in constructing or protecting the cribs would prevent such losses.

Small grains.—The rat in America has usually been considered a house and barn pest, and little notice has been taken of its destructiveness in fields. As a matter of fact, in some localities brown rats, and also common house mice, swarm in the fields, especially in summer.

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[a] Am. Agr., vol. 33, p. 300, 1874.

[b] Trans. Am. Inst., 1866–67, p. 347.

[c] Mo. Valley Farmer, April, 1907.

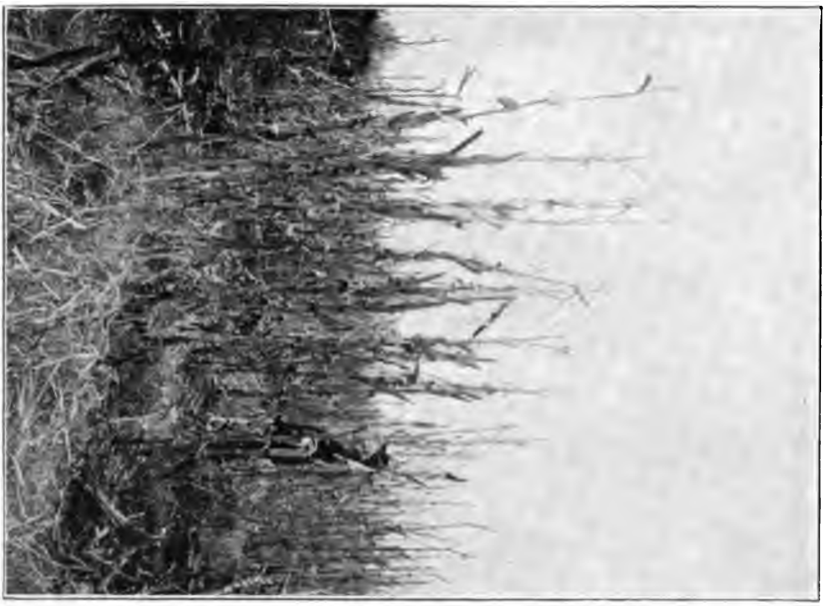

FIG. 1.—A CORNFIELD DEVASTATED BY BROWN RATS.

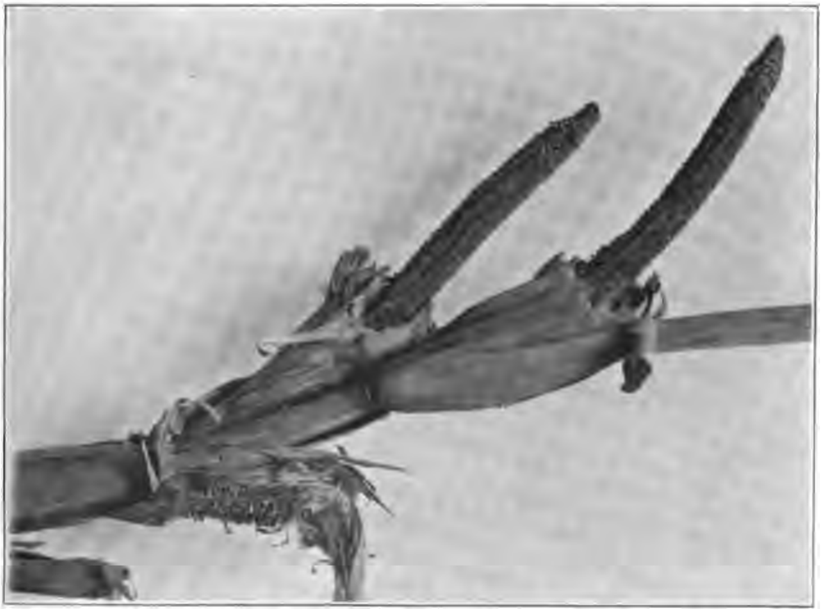

FIG. 2.—A SINGLE CORNSTALK RUINED BY BROWN RATS.

The permanency of the rat's stay in any place is merely a question of food supply. As long as cribs and stables furnish plenty, rats remain in them, but in summer the harvest field and the wheat stacks prove equally if not more attractive, and rats roam far afield.

The small grain crops—wheat, rye, barley, oats, and the like—during growth and until they leave the farmer's hands are constantly dwindling in quantity through inroads made upon them by rats, and these animals continue to prey upon them at every stage of their progress from the field to the consumer. Rats take toll not only from the portion set apart for human food, but even from feed box and manger, as well as from hog trough and outdoor field lot. Bran and chopped grains are as acceptable to rats as whole grain.

The destruction of feedstuffs by rats is a serious loss not only on the farm but in almost every city and village in the whole country. Often through carelessness or the indifference of servants, the bin or barrel in which feed is kept is left uncovered, and rats fairly swarm to the nightly feast. In some cases investigated in Washington, D. C., the loss was equal to 5 or 10 percent of the grain bought. A grocer was buying feed for two horses and several hundred rats; the horses were fed at regular intervals, the rats nearly all the time. In the cases of establishments keeping from fifty to a hundred horses, the loss of feed in the course of a year often amounts to a large item.

Rats are very fond of malt, and in malt houses and breweries constant watchfulness is necessary to prevent losses. Mills, elevators, and warehouses in which grain and feedstuffs are stored are likewise subject to invasions of the animals. Also the destruction of sacks, barrels, and bins is a large item of loss.

Rice.—Rats and mice injure rice fields in the South. The brown rat burrows freely in the dikes and is usually the most destructive species, although the introduced roof rat, the native rice rat (*Oryzomys*), and the native cotton rat (*Sigmodon*) also are injurious in some localities. A letter from Alfred Chisholm, of Savannah, written to Doctor Merriam about twenty years ago, gives some details of the abundance of rats—probably several species—in the Georgia rice fields. Mr. Chisholm says:

> Rats do almost if not quite as much damage [to rice] as birds. * * * It is a matter of fact that Col. John Screven had killed on his Proctor plantation (400 acres of rice lands) over 17,000 rats; and on the Delta plantation (1,000 to 1,200 acres) there were killed by actual count 30,000. These rats were killed during the winter and spring of the same year. During the "stretch" flow, the rats will swim out into the fields from their holes in the dikes and eat every grain of rice left exposed, their depredations being carried on mostly at night.

Arsenic was used to poison the rodents, some planters having each purchased from 50 to 100 pounds of the poison.

Sugar cane.—In nearly all countries that produce cane sugar the planters experience serious loss from rat depredations. The animals cut down and eat the ripening canes, usually selecting a fresh one at each attack. Recent complaints of serious losses to cane planters in Porto Rico and Louisiana have been received by the Biological Survey.

POULTRY AND EGGS.

The depredations of rats upon poultry are a source of serious loss. The amount of damage varies with the abundance of rats and the care taken to exclude them from the poultry yard; but the total for the entire country is always great. The loss of poultry due to rats is probably greater than that inflicted by foxes, minks, weasels, skunks, hawks, and owls combined. Since harm is usually done at night and the actual culprit is unseen, conclusions as to the identity of the marauder are often mere guesswork, and much of the damage done by rats is blamed upon other animals. Not long since, in a published account of depredations on poultry, the damage was attributed to a skunk. The statement was made that both eggs and young chicks were taken from under a sitting hen without disturbing her. This is a trick peculiar to the rat, and it is evident that a mistake was made as to the identity of the thief.

Where rats are numerous in springtime, they often prey upon young chicks, capturing them in the nest and in and around the coops. I have known them to take nearly all the chicks on a large poultry ranch, and, in the same neighborhood and over a large territory, to destroy nearly 50 percent of the season's hatching. Young ducks, turkeys, and pigeons are equally liable to attack, and where rats are numerous are safe only in rat-proof coops.

A writer in a western agricultural paper states that in 1904 rats robbed him of an entire summer's hatching of three or four hundred chicks.[a] A correspondent of another journal says, "Rats destroyed enough grain and poultry on this place in one season to pay our taxes for three years."[b] When it is remembered that the poultry and eggs produced each year from the farms of the United States have a value of over $600,000,000, it will be seen that even a small percentage of loss aggregates a large sum.

Rats destroy also many eggs both on farms and in cities. Fresh as well as incubated eggs are eaten by these rodents. Commission men and grocers complain much of depredations upon packed eggs. Those at the top of a case are broken by these animals, and parts of the yelks run down and stain the unbroken ones. Often, however, rats carry away eggs without breaking them, and display much ingenuity in getting them over obstacles, as up or down a stairway.

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[a] Homemaker (Des Moines, Iowa), May 27, 1907.

[b] Mo. Valley Farmer, April, 1907.

On a level surface the rat rolls the egg before him, but he can easily carry it between a paw and his neck and chin, while going upon three legs.

A commission merchant in Washington relates that he once stored in his warehouse 100 dozen eggs in a wooden tub with a lid of boards nailed on. Rats gnawed a hole through the tub at the top and carried away all but 28½ dozen, leaving no shells or stains to show that any had been broken.

Rats cause much annoyance and loss to poultrymen by their destruction of feed put out for fowls.

Rats are very destructive to tame pigeons, attacking especially young squabs, but destroying eggs also. They often show great cunning in finding entrances to the cages. A fancier residing in Washington, D. C., missed many of his squabs and was satisfied that the only opening by which an animal could enter was the exit at the top of the flying cage. He closed the opening and set a trap there, in which he caught a large rat. The animal had climbed the wire netting on the outside and descended it on the inside to reach the pigeons.

GAME AND OTHER BIRDS.

The rat is a most serious pest in game preserves. The propagation of game birds, both native and introduced, is now a promising industry in the United States. The rat has already proved itself a foe by destroying both eggs and young of pheasants. Abroad, the game preserver regards the rat as the worst enemy of game. A writer in Chambers' Journal says:

> In a closely preserved country at the end of an average year the game suffers more from the outlying rats of the lordship than from the foxes and the mustelines together. The solitary rats, whether males or females, are the curse of a game country. They are most difficult to detect; for in a majority of cases their special work is supposed to be done by hedgehog, weasels, or stoat.[a]

Another writer says:

> There is little doubt that of late years the worst vermin with which the generality of preservers have had to contend has been the rat. It has increased largely in numbers and in some districts become quite a plague, despite the extraordinary efforts made to deal with its ever-increasing depredations. It is unnecessary to speculate upon the probable cause of this remarkable increase. It is due entirely to the neglect of farmers, preservers, and others to adopt adequate means to deal with the pest.[b]

Our native game birds in the wild state are less subject to rat depredations than imported species. The nests of ruffed grouse are made in woodlands, which rats seldom invade The prairie hen and related species generally nest in places remote from the usual haunts of rats. The quail, or bobwhite, however, often selects a nesting site within the summer range of rats, and many a quail's egg reaches the maws of these animals.

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[a] Chambers' Journal, vol. 82, p. 64, January, 1905.

[b] Practical Game Preserving, by Wm. Carnegie ("Moorman"), p. 349, 1906.

Nests of wild ducks, woodcock, and other marsh birds are frequently destroyed by rats. Terns have been driven from their nesting grounds and entire colonies broken up in this way. Professor Mayer, of the Department of Marine Biology, Carnegie Institution of Washington, wrote, May 3, 1908, that rats had almost exterminated the colony of least terns on Loggerhead Key, Tortugas Islands. They destroyed also nearly all the gulls' and other birds' eggs laid on the key. A more recent letter from Professor Mayer states that, through systematic use of traps and poisons, all the terns hatched during the summer of 1908 were saved.

Rats eat also the eggs of nearly all kinds of ground-nesting song birds, and the real offender is seldom even suspected. Crows, jays, snakes, and skunks get much of the blame for the destruction; and while some of them share in the guilt, rats are, after all, the most serious enemies of song and game birds.

FRUITS AND VEGETABLES.

The damage done by rats to fruits and vegetables while stored in cellars and pits is well known. If any garden vegetable or common fruit is immune to their attacks, the fact has thus far escaped notice. But the extent to which the animals prey upon fruits and vegetables before they are harvested is not generally known. Rats attack ripe tomatoes, melons, cantaloupes, squashes, pumpkins, sweet corn, and many other vegetables in the field, and the depredations are often attributed to rabbits. Often both rats and rabbits take toll from the same field or garden, and the work of the former is unsuspected.

Rats are fond of nearly all small fruits, picking them up from the ground and even climbing grape vines, raspberry or blackberry canes, and currant or gooseberry bushes to obtain the ripe fruit.

The brown rat often feeds upon ripe apples, pears, cherries, and other fruits that have fallen to the ground, but it has been known to climb even to the extremities of the branches to obtain ripe apples.[a] Capt. R. R. Raymond, U. S. Army, records the following:

> Just west of old Fort Clinton, at West Point, N. Y., there was, about twenty-five years ago, a deep hollow, in the bottom of which several cherry trees grew. The hollow was used as a dump and was gradually filled level, but at the time mentioned was the home of a great many Norway rats. I often visited the hollow for cherries and frequently met rats in the trees on the same errand as myself.[b]

Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, D. C., informs the writer that during a single afternoon he shot 28 rats from the branches of a cherry tree growing in the heart of the city. The rats were feeding on the ripe fruit.

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[a] The Field (London), vol. 78, p. 660.

[b] Shields' Magazine, vol. 5, p. 123, 1907.

The brown rat is less of a climber than either the roof rat or the black rat; but in warm countries all three climb trees to a greater extent than in the north. Indeed, it is probable that one of the chief reasons why the brown rat has not been able to displace the others within the Tropics lies in the fact that they are more expert climbers. Both the roof rat and the black rat often nest in trees in hot countries, and as a matter of course feed much upon fruits. During the present attempts to abate the rat nuisance in Honolulu, Hawaii, about one-third of the rats taken have been shot from trees. While all four of the cosmopolitan species of *Mus* are common in Hawaii, those shot are chiefly the roof rat and the black rat.

Among the tropical fruits eaten by rats are oranges, bananas, figs, dates, cocoanuts, and especially the pods of cacao, from which chocolate is manufactured.

Attempts to grow dates in the southwestern United States have shown that thus far a native rat (*Sigmodon*) is the worst enemy of the date in America, but it is probable that the introduced rat will soon find its way into the plantations, displace the native species, and prove a more serious foe.

In many lands rats have proved to be enemies of the coffee-growing industry. A correspondent of The Field (London) writes to that journal as follows: "A coffee plantation in which I have an interest in Central America has recently been infested with rats to such an extent that life is almost unbearable. The place has an extent of several thousand acres, part of which is forest land, and I have noticed the branches of the bigger trees full of the pests in the daytime."[a]

Grapes grown under glass are peculiarly subject to attacks of rats. This is especially true in situations where the surrounding buildings are old and dilapidated.[b]

Rats often destroy fruits and vegetables in transit on steamboats. Tomatoes, cucumbers, sweet potatoes, bananas, oranges, grape fruit, peanuts, and other products shipped by water from the South reach their destination in northern markets with a heavy percentage of damage. Steamship companies usually ignore the claims of shippers or receivers for shortage from this cause; and their legal responsibility has not been established. In view of the practicability of destroying rats on steamers by means of fumigation, and the slight cost of building rat-proof compartments for holding the produce, it would seem that this form of loss should be entirely avoided.

MERCHANDISE IN STORES AND WAREHOUSES.

Next to the loss on grains, the largest item of loss due to rats is on miscellaneous merchandise in stores, markets, and warehouses.

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[a] A. H. G., in The Field (London), vol. 107, p. 787, May 6, 1905.

[b] Gardener's Chronicle, 1861, p. 986.

Food materials of every description are subject to attack, but the destruction of dry goods, clothing, books, leather goods, and so on, is equally serious. Many are gnawed to secure material for nests; but books and pamphlets, especially the newly bound, furnish food in the glue and paste used in the binding. Leather of certain kinds is peculiarly attractive to rats. Articles made of kid leather are often destroyed, gloves and shoes especially. Shoes made of ordinary leather are seldom injured unless they have cloth tops. Rats often gnaw old harness, attracted probably by the salt left from perspiring horses. New harnesses are seldom injured, except collars and cruppers, to which rats are attracted by the straw or flaxseed in the stuffing. A harness dealer in Washington reports a recent loss of over a hundred new cruppers, valued at about $90.

Lace curtains, silk handkerchiefs, linens, carpets, mattings, and other dry goods in large stores are much damaged by rats; some for the starch which furnishes food, others for nesting materials. Stuffs that have been soiled by rats in passing over them are often rendered unsalable.

Nearly all large dry goods and department stores have heavy losses from rats, amounting in some instances to several hundred dollars a year, in spite of unremitting efforts to destroy the animals. Grocers, druggists, confectioners, and other merchants have similar experiences. Many of them expend large sums every year fighting the pests. Most of our large cities have several so-called expert rat destroyers who operate with dogs, ferrets, poisons, and other means, and who have a large clientage among merchants and hotel managers. These pay yearly stipends of various sums, from $100 to $600, to the rat catchers to keep their premises free from rats and mice. While the stipulated service is not often performed in full, the clients usually regard the expenditures as economical.

FLOWERS AND BULBS.

Rats are recognized pests of the greenhouse and the plant-propagating pit. They attack seeds, bulbs, leaves, stems, and flowers of growing plants. Of flowering bulbs, the tulip suffers most. Hyacinths also are eaten, while narcissus bulbs are apparently immune to attack. Doubtless this is owing to the slightly poisonous qualities of narcissus.

During the winters of 1904–5 and 1905–6 rats destroyed many of the tulips grown on the Potomac flats near Washington. Sometimes several hundred bulbs were taken in a single night. Hyacinths were injured to a less extent. Traps and poisons made heavy inroads upon the numbers of rats, and probably about 60 percent of the tulips and 90 percent of the hyacinths were saved each season.

Rats attack flowering plants in the greenhouse or conservatory as well as house plants elsewhere. They eat pinks, carnations, and roses, cutting the stems off clean, and denude geraniums of both flowers and leaves. In stores and markets infested by rats carnations can not be left exposed without being eaten. Next to carnation growers, the growers of chrysanthemums are the greatest losers, for rats attack the choicest blooms even in exhibition rooms.

FIRES CAUSED BY RATS.

In the museum of the Royal United Service Institution, Whitehall, London, some years ago, a rat nest was exhibited bearing the following note:

> Rat's nest and young. This nest was set on fire by a lucifer match ignited by the old rat as she worked it into her nest. A fire was nearly caused thereby on H. M. S. *Revenge.*—Lieut. A. H. Gilmore, R. N.[a]

It is generally believed that rats and mice cause fires by igniting matches with their teeth. The testimony of chiefs of fire departments and adjusters of fire-insurance claims confirms this belief, and many specific instances have been given of fires caused in this way. A fire which resulted in the partial destruction of the Sultan's palace at Scutari, Asia Minor, in 1856, had such an origin. During 1907 the fire department of Washington, D. C., gave a similar explanation of a fire which seriously damaged a large store and its contents.

Manufacturers of matches often dip them in paraffin to protect the phosphorus. The paraffin is attractive to rats and mice, and the matches are often carried under floors and behind partitions, where they are subsequently gnawed. Paper and other combustible materials collected by the animals add to the danger of fires. Moreover, since the heads of phosphorus matches contain from 14 to 17 percent of phosphorus, it does not require actual gnawing by rats to ignite them. Hot weather, excessive heat from furnaces, or friction of any kind may effect the same result as the teeth of rats, when the matches have been carried into a nest made of combustibles.

Fires in mills and warehouses have been traced to the spontaneous ignition of oily and fatty rags or waste carried under floors by rats or mice. Cotton mills are said to be peculiarly subject to fires from this cause.

Phillip's warehouse, Church street, London, was twice set on fire and damaged by reason of gas leaks. In both instances the lead gas pipe leading to the meter had been eaten through by rats, and the escaping gas was accidentally set on fire by workmen who were searching for the leak.[b] In a similar instance of gas leak caused by rats in a London private residence, no fire resulted, but a sleeping family of four persons narrowly escaped death by asphyxiation. An inspector in the employ of the Washington Gas Light Company recounts a similar instance in that city where pipes were gnawed by rats, but fortunately it occurred when the inmates were awake.

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[a] Hardwicke's Science Gossip, vol. 5, p. 142, 1869.

[b] Hardwicke's Science Gossip, vol. 10, p. 73, 1874.

The most common way in which rats cause fires is by gnawing away the insulating covering from wires used in electric lighting, where the wires pass under floors or inside of partitions. The insulating materials are used for nests, which rats often build of combustibles placed in contact with the naked wires. Insurance companies, a few years ago, estimated the fire loss in the United States due to defective insulation of wires at $15,000,000 yearly; and since rats and mice are the chief agents in impairing the insulation after the wires are in place, a large part of the above sum must be charged to these animals.

Rats often do mischief by gnawing the insulating covering of telephone wires to obtain the paraffin which it contains. The accompanying illustration (fig. 1) is from a photograph of wires gnawed by rats August 20, 1908, where these wires passed through a partition in rooms occupied by the Biological Survey.

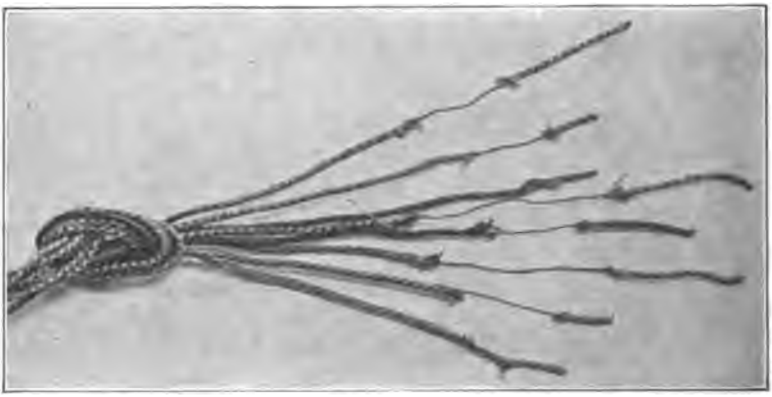

FIG. 1.—Telephone wires gnawed by rats.

DAMAGE TO BUILDINGS AND FURNITURE.

The damage to houses and furniture by rats constitutes a large item. They burrow under foundations or through the plaster in a stone wall and admit streams of water that eventually weaken or undermine the structure itself. They seem to be able to penetrate almost everything except stone, brick, cement, glass, and iron. They gnaw into a grain bin, or through a wainscoting, a floor, or a door in a single night. In the same way they enter chests, wardrobes, bookcases, closets, barrels, and boxes for the stores within. Almost every old dwelling in the country bears abundant evidence of its former or present occupancy by rats. Often depreciation in value of houses and furniture is due largely to marks left upon them by rats—marks that paint and varnish can not hide.

Damage to dwellings is even more serious. The decay of sills and floors is often hastened by contact with wet soil brought up by rats. Rats gnaw through lead pipes or wooden tanks to obtain water, and sometimes before the leak is discovered, ceilings, wall decorations, and floor coverings are flooded and practically ruined. All this is waste of a tangible kind and a constant drain on the prosperity of the people.

MISCELLANEOUS DAMAGE.

Like the muskrat, the common brown rat burrows into embankments and dams, often causing extensive breaks attended with serious loss. At State and National fish hatcheries rats cause much trouble by burrowing into embankments and gnawing through wooden tanks.

Rats often gnaw the hoofs of horses until the feet bleed. Several keepers of livery stables and dealers in horses in Washington, D. C., have had animals thus injured. Brushing the hoofs with dilute carbolic acid is a preventive.

Rats have been known to kill young lambs and pigs and to attack very fat hogs and eat holes in their bodies, causing death. Farrowing sows have been killed by rats gnawing their teats until blood poisoning resulted.[a] In a similar way, they sometimes attack the ears of pigs and shoats and cause their death by the gradual bloodletting.

Many accounts of rats attacking human beings have been published. The modern newspaper reporter seems to delight in harrowing tales of this character, most of which are the product of fertile imagination. Rats will fight if closely cornered or made desperate by lack of food, but many persons already have an unreasoning fear of the animals, which ought not to be intensified by exaggeration.

Rats often carry away valuable articles to use in constructing their nests. The following were found in a single nest: Three bed-room towels, 2 serviettes, 5 dust cloths, 2 pairs linen knickerbockers, 6 linen pocket handkerchiefs, and 1 silk handkerchief. The same rat had carried away and stored near its nest for food 1½ pounds sugar, a pudding, a stalk of celery, a beet, carrots, turnips, and potatoes.[b]

Rats in London warehouses and on shipboard do much damage to ivory in bulk. They gnaw the tusks, usually selecting the freshest and most valuable specimens.

A form of loss by rats once common on ships is not so prevalent now, owing to the more common use of metal in the construction of tanks and bulkheads. This was the perforation of wooden partitions and the damaging of merchandise and ship stores by water.

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[a] Moline (Ill.) Evening Mail, April 25, 1904.

[b] The Field (London), vol. 77, p. 46, 1891.

The extensive use of tinned provisions has also greatly diminished the losses to ship stores.

The destruction of mail sacks and their contents by rats during transportation on ships and at railway stations is a common source of loss. Grain sacks and bagging of all kinds are injured by rats more than by wear.

EXTENT OF DAMAGE BY RATS AND MICE IN CITIES.

During January and February, 1908, the writer personally interviewed about 500 business men in Washington and more than 100 in Baltimore for the purpose of securing data upon which to base an estimate of the probable amount of injury done to property by rats and mice in cities. The persons interviewed included dealers in various kinds of merchandise, feeders of horses, managers of hotels and restaurants, and manufacturers. The inquiries included all sections of the two cities and small dealers as well as large. Estimates of losses experienced during the calendar year 1907 were asked for, and, while some of the responses were mere guesses, the losses reported furnish a fairly reliable basis for averages.

Of 499 firms interviewed in Washington, 71 reported no losses, 83 were unable to give estimates, and 345 reported damages aggregating $36,100. Of the firms seen, no account was taken of about two score alien dealers in groceries or fruits who, probably because of fears of health inspection, would not admit that they were troubled by rats or mice, although evidences of rat damage were plainly visible in their stores.

The whole number of firms in the city engaged in the lines of business investigated is about 4,500. If those whose reports were considered had average losses, the total for the city would be upward of $300,000; but, to avoid exaggeration, a probable average per firm in each kind of business was calculated separately. With reasonable reductions made in this way, the total loss on merchandise in the city was estimated at $193,615. The several lines of trade not included would increase the total for the entire city to more than $200,000.

Besides the above, great loss is experienced in injury to buildings—public, business, and private. The loss on furniture and fixtures also is great. If we estimate the losses in private residences—including personal property and food destroyed, depreciation of property, and the cost of traps, poisons, cats, dogs, and other means of fighting rats—as averaging $4 for each residence, the total amounts to $200,000 a year also. It is conservative to place the entire yearly loss to the people of Washington from rats and mice at $400,000.

Inquiries in Baltimore developed the fact that, in proportion to amount of business and population, the damage from rats and mice is fully as great as in Washington. The portion of Baltimore rebuilt since the great fire of February, 1904, has been reasonably free from rats until the past year. However, many of the large modern buildings erected in the burnt district are now infested with rats. Losses from rats in the markets of Baltimore are less than in those of Washington, not because rats are scarcer, but because Baltimore enforces more stringent regulations as to the storing of goods and the arrangement of fixtures in the stalls. Based on its population and commercial importance as compared with Washington, the total losses exceed $700,000 a year. If similar conditions hold for all cities of over 100,000 inhabitants in the United States, as they probably do, depredations of rats and mice in these centers of population entail a direct loss to the residents amounting to the enormous sum of $20,000,000 annually.

RATS AND PUBLIC HEALTH.

The most serious charge against rats grows out of their relation to human health. It is now positively known that rats are chiefly responsible for the spread of bubonic plague, a malady which, in spite of modern methods of fighting it, has within the past dozen years destroyed over 5,000,000 human beings in India alone. During 1907 the deaths from plague in India were 1,200,000, and by May, 1908, the present epidemic, which started in China in 1894, had invaded all the continents and infected 51 countries of the world. The identity of plague in man with plague in the rat was proved some years ago, but the particular means by which the disease is transmitted from rat to rat and from rat to man was not clearly understood until recently. The fact that fleas carry the infection was set forth positively as early as 1902, but the conclusions of the India Plague Commission have finally removed all doubt upon the subject. The results of two years of exhaustive research were recently published in a pamphlet which thus summarizes the conclusions concerning bubonic plague:

1. Bubonic plague in man is entirely dependent on the disease in the rat.
2. The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.
3. A case of bubonic plague in man is not in itself infectious.
4. A large majority of plague cases occur singly in houses. When more than one case occurs in a house the attacks are generally simultaneous. [This proves that there is no soil infection.]
5. Plague is usually conveyed from place to place by imported rat fleas which are carried by people on their persons or in their baggage. The human agent not infrequently himself escapes infection.
6. Insanitary conditions have no relation to the occurrence of plague, except in so far as they favor infestation by rats.
7. The nonepidemic season is bridged over by acute plague in the rat, accompanied by a few cases amongst human beings.[a]

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[a] Etiology and Epidemiology of Plague, p. 93. Calcutta, 1908.

Experiments were made with two species of rat fleas, both of which were found to carry the infection. Probably all kinds of rat fleas transmit plague, while those that commonly infest dogs, cats, and man do not.

The conclusions of the Plague Commission had already been practically accepted by medical men in most parts of the world, and recent outbreaks of plague were followed by active measures for the destruction of rats. In India, as early as 1905, the authorities of the United Provinces (Agra and Oudh) began a persistent war upon the animals. Rewards were offered for killing rats, and traps were given to the people. In the four centers of population—Agra, Allahabad, Bareli, and Badaun—a total of 416,403 rats were killed before the close of the first year.[a] In Athens, Odessa, Oporto, Glasgow, and other European cities systematic, but on the whole unsuccessful, efforts were made to exterminate these animals.

Similar attempts to get rid of rats have been made since September, 1907, in some of the Pacific ports of our own country, particularly in San Francisco, where up to February, 1908, 77 deaths from plague occurred. Traps, poisons, bounties, and other means were employed to reduce the number of rodents. During the first four months of warfare under the direction of the United States Marine-Hospital Service about 130,000 of the animals were destroyed in San Francisco and vicinity. In the early months of 1908 the work of destruction was stimulated by increased bounties, and for a time the number of rats killed averaged about 7,000 per week. Up to May, 1908, 278,000 rats were captured in the city and it was estimated that half a million had been poisoned.

From May, 1908, to January 1, 1909, 115,869 rats were trapped and 9,797 were found dead in San Francisco. On an average, over 140,000 poisoned baits per week were placed, but as a matter of course the number of dead rats discovered was only a small percent of the total number killed by poison. The last rat found infected with plague bacillus was taken October 23, 1908, but no human cases of the disease have occurred in the city since January, 1908.

In Honolulu, Hawaii, active operations against rats have been reported since May 23, 1908. During the 30 weeks ending December 12, 1908, 20,288 rats were trapped and 3,528 shot from trees in the city. None of those examined was infected with plague bacillus.

But rats disseminate diseases other than bubonic plague. Trichinosis among swine is probably perpetuated entirely by rats. The occurrence of trichinæ among herbivorous animals is very rare, and in the hog can result only from its eating the flesh of animals infested with the parasite. The only two animals of the farm known to be subject to the parasite are the rat and the hog itself. Pork becomes trichinous, then, only when swine eat the flesh of infested rats or hogs. Country slaughterhouses, where rats are abundant and swine are fed on offal, are the chief sources of trichinous pork.[a]

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[a] Report on Plague in the United Provinces by Maj. Chator White, 1906.

A writer in The Spectator (London) states that septic pneumonia is sometimes the result of drinking water from shallow wells in which rats have been drowned and their bodies left to decay. He adds further that rats are "also disseminators of every kind of disease which can be conveyed into and from drains; for of all highways a rat loves a drain the best."[b] What visions of typhoid, scarlet, and malarial fevers, diphtheria, and other malignant diseases are aroused by such a statement! It is probable that many disease germs adhere to rats' feet and are thus carried to places where they threaten human health. Ptomaines are said to be sometimes conveyed to meats or other human foods in this way. On the whole, hygienic considerations furnish the strongest argument for the extermination of rats.

UTILITY OF THE RAT.

Except that to a limited extent rats act as scavengers, they render no important service to man. In former times, doubtless, their work as scavengers in cities was of considerable value, but modern methods of garbage disposal make this service insignificant.

MEANS OF REPRESSING RATS.

It is not creditable to our civilization that a creature so noxious as the rat should continue to flourish. The fact that it lives in surroundings of dirt, disorder, and waste, while it preys on the best of our productions, makes its constant increase a matter for chagrin. The animal has developed such an extraordinary degree of sagacity under persecution that attempts to exterminate it have been largely wasted. The failure of these efforts has not been due to lack of effective methods so much as to negligence and the absence of concerted action. Besides, as already stated, we have rendered our work abortive by continuing to provide subsistence and hiding places for the rat. When once these advantages are denied to the animals, persistent and concerted application of the best methods of destroying them will prove far more effective.

The more important means of fighting rats are considered under five captions: (1) Natural enemies of the rat, (2) rat-proof construction of buildings, (3) keeping food from rats, (4) driving away rats, (5) destroying rats.

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[a] Circular 108, Bureau of Animal Industry, p. 1, 1907.

[b] The Spectator, vol. 95, p. 603, October 21, 1895.

NATURAL ENEMIES OF THE RAT.

The extent to which predatory mammals and birds feed upon rodents should be more generally understood. Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey upon them. Too often the slaughter is based upon ignorance of the animal's real economic value. Animals that on the whole are decidedly beneficial are habitually destroyed because they occasionally transgress. Thus, warfare is made on the skunk and many kinds of hawks and owls that occasionally destroy a chicken or a game bird but which habitually subsist upon harmful insects and rodents. Among the natural enemies of the rat are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, and a few other mammals. To these must be added the domestic dogs, cats, and ferrets.

HAWKS.

Several kinds of hawks feed on rats, usually during the season when the latter infest the fields; for hawks, because of persecution, do not often stay about farm buildings. Hence, ordinarily hawks have few opportunities to prey on these denizens of house and barn.

In open fields, however, rats often come out in daytime, especially in early morning and late afternoon. Hawks are then on the lookout for prey, and many a rat is killed by them. The species of hawks that most commonly feed upon rats are: The buzzard hawks (*Buteo*), including the red-tailed (*Buteo borealis* and subspecies), the red-shouldered (*B. lineatus*), the broad-winged (*B. platypterus*), and the Swainson (*B. swainsoni*); the rough-legged hawks (*Archibuteo*), two species; and probably the marsh harrier (*Circus hudsonius*).

OWLS.

In destroying rats owls are more efficient than hawks, because they hunt at night, when the rodents are most active. All American owls except the most diminutive species kill rats. Even the little screech owl (*Megascops asio*) often feeds upon the young.

Of all our owls, the barn owl (*Strix pratincola*) stands at the head in destructiveness to rats, since it often makes its home about farm buildings. Dr. A. K. Fisher, of the Biological Survey, has examined the pellets, or castings, of a pair of barn owls that live in the tower of the Smithsonian Institution in Washington and found in them skulls of 172 rats (*Mus norvegicus*). In addition, these birds had destroyed 1,285 field mice and 452 house mice.

Dr. John I. Northrop found a nest of the barn owl on Andros Island, Bahamas, which held two young birds not yet able to fly. The ground around the nest was covered with pellets which contained remains of the black rat and no other species.[a] This circumstance shows that the birds feed on whatever rodents are most abundant and most easily obtainable. In the event of a general invasion of rats in any locality where these owls stay, the birds would be most efficient aids in their destruction.

The great horned owl (*Bubo virginianus*) is the largest of our resident owls, and usually is a most useful bird. True, he captures the farmer's fowls when roosting unsheltered on fences or in trees, but such loss is easily prevented. The owl captures many rats, especially when they are plentiful. Mr. Charles Dury, of Ohio, in 1886 published a letter from Θ. E. Niles in which the latter states that under one nest of the great horned owl he counted 113 dead rats.[b]

The snowy owl is a rather rare winter visitor in the United States. Usually it arrives when the ground is covered with snow and ordinary food is scarce. Near barns, outbuildings, and stacks the brown rat is its chief reliance, and if undisturbed these owls will stay for several weeks in the same locality feeding on these pests.

The practice of killing hawks and owls should be discouraged. Game preservers, especially, should realize that the birds of prey would, if permitted to live, destroy rats that in the course of a year do ten times as much damage to game as the birds. The custom of paying bounties for killing birds of prey is a most unwise expenditure of public funds, harmful in its immediate results and pernicious in its influence on the community.

WILD MAMMALS.

The wild mammals that destroy rats are not numerous, and few of them resort much to localities favored by rats. Chief among those that do good work for the farmer in rat destruction are skunks, minks, and weasels. These all resort to the haunts of the rat, and are, in the main, useful. The mink is the only one that does damage enough to nearly offset its usefulness in destroying farm pests.

Skunks.—Skunks are excellent ratters, and when they take up their abode on the premises of the farmer, will speedily destroy or drive away all rats and mice. This statement applies to both the large skunks (*Mephitis*) and the little spotted skunks (*Spilogale*). Unfortunately they are seldom allowed to tenant the premises without being molested by either dogs or men. When thus disturbed, the skunks emit the characteristic secretion, which is almost their only defense, against enemies. Undisturbed, they are quite inoffensive and will stay about the farm buildings until rats and mice are no longer to be had.

Skunks usually hunt by night, and hence poultry properly housed is safe from them. The larger skunks can not climb, and do not capture fowls that roost on elevated perches. Indeed, so few skunks ever kill poultry that warfare on the skunk family is not justified. Besides destroying mice and rats, skunks are invaluable to the farmer as consumers of noxious insects, particularly cutworms, army worms, tobacco worms, white grubs, May beetles, grasshoppers, crickets, and sphinx moths.

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[a] The Auk, vol. 8, p. 75, 1891.

[b] Jour. Cincinnati Soc. Nat. Hist., vol 8, p. 63, 1886.

Weasels.—Weasels are good ratters and mousers. Several of the American species come about buildings and often perform excellent service in destroying rodents. They are more destructive to poultry than the skunk, for they can enter poultry houses through smaller openings, can climb to the roosts, and usually take more than one victim at a time.

These traits make them efficient in destroying rodents also. The smaller species of weasels can follow a rat into its burrow and to nearly all its usual retreats. A single victim rarely satisfies it, and in a very short time it clears stackyard or shed of rats and mice.

Our largest species of weasel, the black-footed ferret (*Putorius nigripes*), occasionally deserts its wild haunts and comes about buildings in search of rats and mice. At Hays, Kans., during the summer of 1905, a black-footed ferret took up its abode under the board sidewalk in the business part of the town, and the squealing of its victims was frequently heard.

As concerns the destruction of poultry by weasels, the same care necessary to exclude rats from the poultry house and yard will keep out the weasel also. When so excluded, the weasel does no harm about the premises, but may be depended upon to drive out or destroy the rats.

Minks.—Minks surpass weasels in their destructiveness to poultry, and they feed on fish also. While excellent ratters, the increasing value of mink furs causes the animals to be so closely hunted that in most parts of the country they now exert little influence upon the numbers of rodent pests or upon the fortunes of the poultry grower or the fish culturist.

The mongoose.—Among the natural enemies of rats are the various species of mongoose (*Herpestes* and *Mongos*). The mongoose was introduced into Jamaica and Hawaii many years ago to stay the depredations of rats upon sugar cane and other products. While it kills many rats, it does not exterminate them, and it has proved a great scourge to poultry and native birds. It destroys also many lizards and other insectivorous animals. For these reasons its importation into the United States is prohibited by law.

RAT-PROOF CONSTRUCTION.

The best way to exclude rats from buildings, whether in city or country, is by the use of cement in construction. As the advantages of this material are coming to be generally understood, its use is rapidly extending to all kinds of buildings. Dwellings, dairies, barns, stables, chicken houses, ice houses, bridges, dams, silos, tanks, cisterns, root cellars, hotbeds, sidewalks, and curbs are now often made wholly of cement. The processes of mixing and laying this material require little skill or special knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction. Illustrated handbooks are often furnished free by cement manufacturers.

Many modern public buildings are so constructed that rats can find no lodgment in the walls or foundations, and yet in a few years, through negligence, such buildings often become infested with the pests. Sometimes drain pipes are left uncovered for hours at a time. Often outer doors, especially those opening on alleys, are left ajar. A common mistake is failure to screen basement windows which must be opened for ventilation. In whatever way the intruders are admitted, when once inside they proceed to intrench themselves behind furniture or stores, and it is difficult to dislodge them. The addition of inner doors to vestibules is an important precaution against rats. The lower part of outer doors to public buildings, especially markets, should be reinforced with light metal plates to prevent the animals from gnawing through.

In constructing dwelling houses the additional cost of making the foundations rat-proof is slight as compared with the advantages. The cellar walls should have concrete footings, and the walls themselves be laid in cement mortar. The cellar floor should be of "medium" rather than "lean" concrete, and all water and drain pipes should be surrounded with concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or sharp bits of crockery or stone.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with wire netting is a most necessary precaution to exclude rats.

Rats sometimes gain access to houses by way of vines growing on the outer walls and reaching to open windows, and the means by which the animals come and go is a mystery to the household. Old growths of Virginia creeper or ivy often furnish such ladders for rats.

Rats often enter houses from sewers by way of soil pipes leading into water-closets. A number of instances of this kind were reported to the writer as having occurred in the city of Washington during the past year. The careful construction of drains and the use of traps that rats can not pass through will prevent such invasion of dwellings.

In cities, aside from dwellings, the sewers, wharfs, stables, and outbuildings are the chief refuges for rats. Modern sewers are used by the animals only as highways and not as permanent abodes; but old-fashioned brick sewers often furnish nesting crannies. Openings from sewers to streets may easily be screened against rats, but with modern sewers this is unnecessary.

Wharfs, stables, and outbuildings in cities should be constructed with a view to exclude rats. Cement is the chief means to this end. Old, tumble-down buildings and wharfs should not be tolerated in any city, but should be condemned and destroyed.

Almost everywhere, in country, village, and city, the wooden floors of sidewalks, areas, and porches are commonly laid upon timbers resting upon the ground. Under these floors rats are safe from most of their enemies. Only municipal action can completely remedy these conditions, but all such rat harbors should be destroyed and replaced by cement floors. Considering durability, healthfulness, and other advantages, this material is the cheapest that can be used. The floors of wooden porches should always be well above the ground. Rats often undermine brick walks or areas.

Granaries, corncribs, and poultry houses may be made rat-proof by a liberal use of concrete in the foundations and floors; or the floors may be of wood resting upon concrete. Objection has been urged against the use of concrete floors for horses, cattle, and poultry, because the material is too good a conductor of heat and the health of the animals suffers from contact with floors of this kind. In poultry houses, dry soil or sand may be used as a covering for the cement floor; and in stables, a wooden floor resting on the concrete is just as satisfactory so far as the exclusion of rats is concerned.

The common practice of setting corncribs on posts with inverted pans at the top often fails to exclude rats, because the posts are not high enough to place the lower cracks of the structure beyond reach of the animals. The posts should project at least 3 feet above the surface of the ground, for rats are excellent jumpers. But a crib built in this manner, though cheap, is unsightly.

For a rat-proof crib a well-drained site should be chosen. The outer walls, laid in cement, should be sunk about 20 inches into the ground. The space within the walls should be thoroughly grouted with cement and broken stone and finished with "rich" concrete for a floor. Upon this the structure may be built. Even the walls of the crib may be concrete. Corn will not mold in contact with them, provided there is good ventilation and the roof is water-tight.

However, there are cheaper ways of excluding rats from either new or old corncribs. Rats, mice, and sparrows may be effectually kept out by the use of either an inner or an outer covering of galvanized-wire netting of half-inch mesh and heavy enough to resist the teeth of rats. The netting in common use for screening cellar windows is suitable for covering cribs. As rats can climb the netting, the entire structure must be screened.

KEEPING FOOD FROM RATS.

The effect of an abundance of food on the breeding of rodents has already been mentioned. Well-fed rats mature quickly, breed often, and have large litters of young. Besides limiting reproduction, scarcity of food will make the measures to destroy the animals by traps, poisons, or bacterial cultures far more effective.

The general rat-proofing of buildings is the most important step in limiting the food supply of rats. But since much of the animals' food consists of garbage and other waste materials, it is not enough to bar rats from markets, granaries, warehouses, and private food stores. Garbage or offal of any kind must be so disposed of that rats can not obtain it.

In cities and towns an efficient system of garbage collection and disposal should be established by ordinances. Waste from markets, hotels, cafés, and households should be collected in covered metallic receptacles and emptied each day. Garbage should never be dumped in or near towns, but should be utilized or promptly destroyed by fire.

Rats find abundant food in country slaughterhouses; reform in the management of these is badly needed. It is a common practice to leave offal of slaughtered animals to be eaten by both rats and swine. Such places are not only centers of rat propagation, but are the chief means of perpetuating trichinæ in pork. All this should be changed by law. The offal should be promptly cremated or otherwise disposed of. There is no reason why country slaughterhouses should not be as cleanly as constantly inspected abattoirs.

Another important source of rat food is the remnants of lunches left by employees in factories, stores, and public buildings. This food, which alone is sufficient to attract and sustain a small army of rats, is commonly left in waste baskets or other open receptacles. Strictly enforced rules requiring all remnants of food to be deposited in covered vessels would make trapping far more effective.

If buildings are infested with rats, wire-screened compartments should be used for storing food. Many merchants now keep flour, seeds, meats, and the like in wire cages, and the practice should be general. Ice boxes and cold-storage rooms may be made proof against rats by an outer covering of heavy wire netting of half-inch mesh. Steamboat companies engaged in carrying high-priced southern produce to northern markets can, at small expense, protect the vegetables or fruits in screened compartments on both docks and vessels.

DRIVING AWAY RATS.

Many devices have been recommended for driving rats from premises. Some are based upon superstitions and have no merit; others are more or less practical. It should be remembered, however, that the community gains nothing when rats merely migrate from one dwelling or plantation to another. Nothing short of destruction of the animals is an adequate measure of relief. Occasionally, however, under certain circumstances it may be desirable to drive rats from a particular place, dwelling, or apartment.

Rats frequently shift their quarters, thus making it difficult to judge accurately the success of measures employed against them. They often of their own volition move to new grounds, and the change is wrongly attributed to means used to drive them away or to destroy them. This explains the diverse results that sometimes follow applications of the same remedy.

Among methods for driving away rats that have proved useful under some circumstances are the following:

1. Freshly slaked lime placed dry in all burrows and runs of rats.
2. Freshly made thin whitewash poured into the rat burrows.
3. A strong solution of copperas (ferrous sulphate) sprinkled in runs and burrow entrances.
4. Chlorid of lime, loose or wrapped in old rags, placed in burrows and runs.
5. Gas tar daubed about the burrow entrances.
6. Powdered red pepper scattered in rat runs and burrows.
7. Caustic potash placed in the burrows and runs.

The following have been so often suggested that they are mentioned here, though they have little to recommend them: Fastening a small bell to the neck of a live rat (by means of wire) and releasing the animal in the infested place; singeing or daubing with gas tar; feeding the rats plaster of Paris mixed with twice its bulk of meal, both dry. Of most of these the writer can not speak from experience. With reference to the last, however, it may be stated that caged rats ate plaster of Paris, mixed with flour or meal in various proportions, freely and without injury. The setting quality of the plaster was first carefully tested. Several days after the experiment the rats were killed and examined. Their digestive organs were in normal condition. These experiments completely disprove the often-repeated statement that plaster of Paris mixed with meal solidifies in the stomachs of rats. It may be stated further that the same rats ate freely and without harm pieces of cork and sponge that had been fried in lard. The results show that these substances, so frequently recommended, have no value in killing rats.

DESTROYING RATS.

The Biological Survey has made both laboratory and field experiments with various agencies for destroying rats. The results obtained form the chief basis for the recommendations set forth in the following pages.

TRAPS.

Owing to their cunning it is not easy to clear premises of rats by trapping. A few adults refuse to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals. For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called guillotine traps, are of many designs, but the more simply constructed are to be preferred. Probably those made entirely of metal are the best, as they are more durable and are less likely to absorb and retain odors.

In illustration of the effectiveness of traps it may be related that about three years ago a large department store in Washington experienced heavy losses of gloves, lace curtains, and other merchandise from rat depredations. After they had made many unsuccessful attempts to abate the nuisance, the managers were advised to try the improved traps. As a result 136 rats were killed during the first 20 nights, when the losses practically ceased, and trapping has been continued in the store ever since with satisfactory results.

Guillotine traps should be baited with small pieces of Vienna sausage (Wienerwurst) or fried bacon. A small section of an ear of corn is an excellent bait if other grain is not present. The trigger wire should be bent inward to bring the bait into proper position to permit the fall to strike the rat in the neck, as shown in the illustration (fig. 2).

Other excellent baits for rats are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, corn, and sunflower, squash, or pumpkin seeds. Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in winter. When seed, grain, or meal is used with a guillotine trap, it is placed on the trigger plate, or the trigger wire may be bent outward and the bait sprinkled under it.

When rats are numerous, the large French wire cage traps can be used to advantage. They should be made of stiff, heavy wire, well reenforced. Many of those sold in hardware stores are useless, because a full-grown rat can bend the light wires apart and escape.

Cage traps should be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a large catch may be expected, especially of young rats. As many as 25, and even more, partly grown rats have been taken at a time in one of these traps.

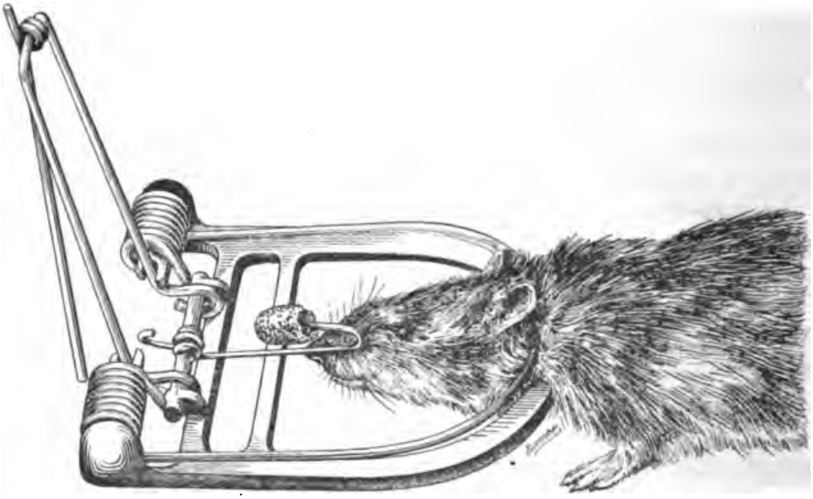

FIG. 2.—Method of baiting guillotine trap.

The editor of The Field (London), commenting on a letter from a correspondent who complained of lack of success with the cage trap, says:

> Rats are not fools and men are not always wise enough to circumvent them. We have had this trap lying in the open and not a rat would touch it, but taken up and a little refuse fish put into it and an old mat over it, we got some lovely specimens next morning. A successful trapper says that even when he gets a rat in this trap he does not disturb it, but feeds it, and sometimes he has 8 or 9 other rats come in to keep it company.[a]

The writer has had excellent success by concealing a cage trap under a bunch of hay or straw, and has found by experience that a decoy rat is useful. A commission merchant in Baltimore places the baited cage trap inside of a wooden box having a hole in one end and against which the opening of the trap is fitted. The box is then covered with trash and large catches are made.

Notwithstanding the fact that sometimes a large number of rats may be taken at a time in cage traps, in the long run a few good guillotine traps intelligently used will prove more effective.

The old-fashioned box trap set with a figure-4 trigger is sometimes useful to secure a wise old rat that refuses to be enticed into a modern trap. Better still is a simple deadfall—a flat stone or a heavy plank—supported by a figure-4 trigger. An old rat will go under such a contrivance to feed without fear.

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[a] The Field (London), vol. 89, p. 692, May 1, 1897.

The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very light bit of cotton under the trigger and setting as lightly as possible. In narrow runs or at the mouth of burrows a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

The best bait to use in trapping is usually food of a kind that the rats do not get in the vicinity. In a meat market vegetables or grain should be used; in a feed store, meat. As far as possible, food other than the bait should be inaccessible while trapping is in progress. The bait should be kept fresh and attractive, and the kind changed when necessary. Baits and traps should be handled as little as possible. Ordinarily, traps should be frequently cleaned or smoked. The use of artificial scents, as oil of anise or rhodium, on the bait is advocated by many, but no doubt their importance has been exaggerated. The experience of the writer is not favorable to their use, but they may do some good by concealing the human odor on the trap.

Barrel trap.—About sixty years ago a writer in the Cornhill Magazine gave details of a trap by means of which it was claimed that 3,000 rats were caught in a warehouse in a single night. The plan involved tolling the rats to the place and feeding them for several nights on the tops of barrels covered with coarse brown paper. Afterwards a cross was cut in the paper, so that the rats fell into the barrel (fig. 3). Many variations of the plan, but few improvements upon it, have been suggested by agricultural writers since that time. Reports are frequently made of large catches of rats by means of a barrel fitted with a light cover of wood, hinged on a rod so as to turn with the weight of a rat (fig. 3).

Fence and battues.—In the rice fields of the Far East the natives build numerous piles of brush and rice straw and leave them for several days until many rats have taken shelter in them. A portable bamboo inclosure several feet in height is then set up around each pile in succession and the straw and brush are thrown out over the top while dogs and men kill the trapped rodents. Large numbers are killed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or haystacks, as well as brush piles.

In a large barn near Washington, a few years ago, piles of unhusked corn shocks were left in the loft and were soon infested with rats. A wooden pen was set down surrounding the piles in turn and the corn thrown out until dogs were able to get at the rats. In this way several men and dogs killed 500 rats in a single day.

Burmese rat trap.—The Burmese use an ingenious and simple method of trapping rats. A large jar with a weighted cover is sunken into the ground (fig. 4). A hole is punched in the side of the jar on a level with the surface of the ground and just large enough to admit a large rat. Paddy (rice) is used in the jar as a bait. A writer states that he saw 72 rats caught in one such trap the first night it was set.[a]

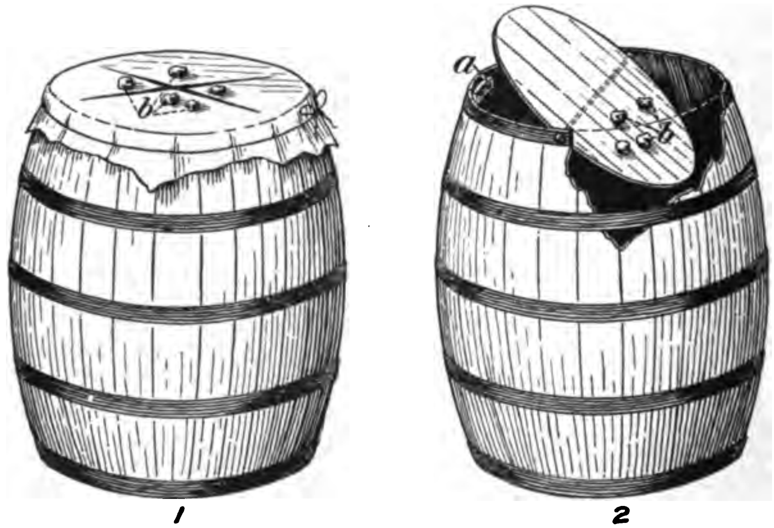

FIG. 3.—Barrel traps: 1, With stiff paper cover; 2, with hinged barrel cover; *a*, stop; *b*, baits.

POISONS.

While the use of poison is the best and quickest way to get rid of rats, the odor from the dead animals makes the method impracticable in occupied houses. Poison, however, may be effectively used in barns, stables, sheds, cribs, and other outbuildings.

Among the principal poisons that have been recommended for killing rats are barium carbonate, strychnine, arsenic, and phosphorus.

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate.[b] This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible, they usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

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[a] The Field (London), vol. 35, p. 286, 1870.

[b] Barium carbonate, as well as some other salts of barium, is often called "barytes." In its native form it is known as "witherite." True barytes is barium sulphate, which is too insoluble for practical use as a poison for rats.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should be placed in rat runs, a small quantity—as a teaspoonful—at a place. If a single application of the poison fails to kill or drive away all rats from the premises, it should be repeated with a change of bait.

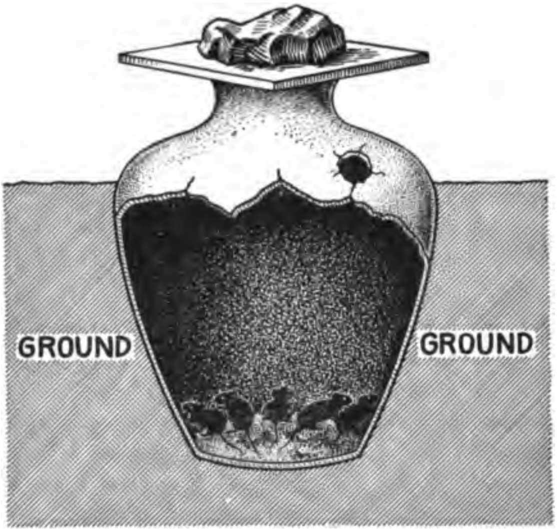

Fig. 4.—A Burmese trap.

Strychnine.—Strychnine is too rapid in action to make its use as a poison for rats desirable in houses, but elsewhere it may be employed effectively. Strychnia sulphate is the form best adapted for use. The dry crystals may be inserted in small pieces of raw meat, Vienna sausage, or toasted cheese, and these placed in rat runs or burrows; or oatmeal may be moistened with a strychnine sirup, and small quantities laid in the same way.

Strychnine sirup is prepared as follows: Dissolve a half ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity of the poison may be prepared with a proportional quantity of water. In preparing the bait it is necessary that all the oatmeal should be moistened with sirup. Wheat is the most convenient alternative bait. It should be soaked over night in the strychnine sirup.

The bitterness of strychnine often prevents rats from eating baits containing the crystals. This trouble may sometimes be overcome by first feeding the baits without the strychnine for several successive nights until suspicion is allayed.

Arsenic.—Nearly all commercial rat poisons have either arsenic or phosphorus as a basis; and while many of them are effective, the poison is often present in quantities too small to be fatal to rats. It has been proved by experiment that sometimes rats have great power of resistance to some poisons, particularly to arsenic. Yet arsenic is an excellent rat poison, as is shown by its continued popularity. Its cheapness commends it to favor; yet the experiments of the Biological Survey show that strychnine, measured by the results obtained, is really the cheaper poison for most rodents.

Powdered white arsenic (arsenious acid) may be fed to rats in nearly any of the baits mentioned under barium carbonate and strychnine. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following, adapted from an English source:

Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Place a tablespoonful at a place in runs frequented by rats.

Phosphorus.—This is probably the most widely used poison for rats and mice, and undoubtedly it is effective when given in an attractive bait. The phosphorus paste of the drug stores is usually dissolved yellow phosphorus mixed with glucose or other substances. The proportion of phosphorus varies from one-fourth percent to 4 percent. The first amount is too small to be always effective, and the last is dangerously inflammable. When home-made preparations of phosphorus are used, there is much danger of burning the person or of setting fire to crops or buildings. In the western States many fires have resulted from putting out home-made phosphorus poisons for ground squirrels, and entire fields of ripe grain have been destroyed in this way. Even with the commercial pastes the action of sun and rain upon them changes the phosphorus and leaches out the glucose until a highly inflammable residue is left.

It is often claimed that when phosphorus is eaten by rats or mice it dries up or mummifies the bodies so that no odor results. The statement has no foundation in fact. Equally misleading is the statement that rats poisoned with phosphorus do not die on the premises. Owing to its slower operation, no doubt a larger proportion escape into the open before dying than when strychnine is used.

The Biological Survey does not recommend the use of phosphorus as a poison for rodents.

Caution.—In the United States there are few laws which prohibit the laying of poisons on lands owned or controlled by the poisoner. Hence it is all the more necessary to exercise extreme caution to prevent accidents. In several States notice of intention to lay poison must be given to persons living in the neighborhood. Poison for rats should never be placed in open or unsheltered places. This applies particularly to the use of strychnine or arsenic on meat.

Poison in poultry houses.—For poisoning rats in buildings and yards occupied by poultry, the following method is recommended: Two wooden boxes should be used, one considerably larger than the other, and each having two or more holes in the sides large enough to admit rats. The poisoned bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over the other. Rats thus have free access to the bait, but fowls are excluded.

The following methods of poisoning rats are quoted as useful under certain circumstances:

"I took a box, made several holes in it, turned it upside down, mixed strychnine and cheese together and put it under the box. I then placed a heavy weight on the box so that no domestic animal could get at it and put it in the granary and corncrib. This poison is best because it acts so quickly that rats do not have time to get back to their holes or crawl where any domestic animal can get at them and they can be gathered up and buried." [a]

A writer in the Agricultural Gazette used barium carbonate on herrings, after first feeding the rats liberally on herrings to give them confidence. After a couple of nights' feeding, the poisoned herrings were substituted. The barytes was rubbed into the herrings with a stick. Many rats were killed.[b]

Use any kind of wooden box, like an old packing case. Make three or four holes in each box large enough to allow a rat to enter. Feed meal for several days; then omit for one day. Then mix arsenic with the meal.[c]

To destroy rats on farms.—Each evening when the cows are milked place a little fresh milk in a shallow pan where the rats can get it.

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[a] A. E. L. in Mo. Valley Farmer for April, 1907.

[b] American Agriculturist, vol. 9, p. 257, August, 1850.

[c] The Field (London), vol. 96, p. 624, October 30, 1900.

Continue this for a week or more until the rats get bold and impatient to get at the milk. Then mix arsenic with the milk and await results. This plan is said to entirely clean a barn of rats.[a]

DOMESTIC ANIMALS.

Among the domestic animals often employed to kill rats are the familiar dog, cat, and ferret.

Dogs.—The value of dogs as ratters can not be appreciated by persons who have had no experience with a trained animal. The ordinary cur and the larger breeds of dogs seldom develop the necessary qualities for ratters. Small Irish, Scotch, and fox terriers when properly trained are superior to other breeds, and under favorable circumstances may be relied upon to keep the farm premises reasonably free from rats.

With some preliminary training most terriers learn to hunt rats independently and thus become doubly useful on the farm. Several terriers owned in Washington are said to have destroyed over 1,000 rats each, and the owner of one of them states that his dog has killed that number in one year. A young terrier kept in the National Capitol is said to have destroyed over 400 rats in that building.

Cats.—However valuable cats may be as mousers, few of them learn to catch rats. The ordinary house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Birds and mice are much more to its liking.

Ferrets.—Tame ferrets, like weasels, are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly overestimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

FUMIGATION.

Rats may be destroyed in their burrows in the fields and along river banks, levees, and dikes by the use of carbon bisulphid. A wad of cotton or other absorbent material is saturated with the liquid and then pushed into the burrow, the opening being packed with earth to prevent the escape of the gas. All animals in the burrow are asphyxiated. Fumigation in buildings is rarely effective, because it is difficult to confine the gases. Moreover, when effective, the odor from the dead rats is highly objectionable.

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[a] E. H. Reihl, in Colman's Rural World, vol. 61, p. 27, January 29, 1908.

Chlorin, carbon monoxid, sulphur dioxid and hydrocyanic acid are the gases most used for destroying rats and mice in sheds, warehouses, and stores. Each is effective if the gas can be confined and made to reach the retreats of the animals. Owing to the great danger from fire incident to burning charcoal or sulphur in open pans, a special furnace provided with means for forcing the gas into the compartments of vessels or buildings is generally employed.

Hydrocyanic-acid gas is effective in destroying all animal life in buildings. It has been successfully used to free elevators and warehouses of rats, mice, and insects. However, it is so dangerous to human life that the novice should not attempt fumigation with it, except under careful instructions. Directions for preparing and using the gas may be found in "Hydrocyanic-acid Gas against Household Insects," by Dr. L. O. Howard.[a]

Carbon monoxid is rather dangerous, as its presence in the hold of a vessel or other apartment is not manifest to the senses, and fatal accidents have occurred during its employment to fumigate vessels.

Chlorin gas has a strong bleaching action upon textile fabrics and for this reason can not be used in many situations.

Sulphur dioxid also has a bleaching effect upon textiles, but less marked than that of chlorin and ordinarily not noticeable with the small percentage of the gas it is necessary to use. On the whole, this gas has many advantages as a fumigator and disinfectant. It is successfully employed also as a fire extinguisher on board vessels.

The port regulations for destroying rats to prevent the introduction of plague and to disinfect merchandise and personal effects of passengers have generally been made to conform to the opinion of health officers that thorough fumigation with sulphur dioxid forced into every part of a ship meets all requirements, and the long delays of quarantine are thus avoided. A number of important steamship companies have fitted their vessels with special apparatus for generating the gas and forcing it into the compartments of their ships, and the authorities of some ports have fitted the docks with such apparatus for use on all incoming vessels.

While the chief object of the port regulations for disinfecting ships is to prevent the introduction of plague and similar diseases, the advantages of having vessels free from rats and other vermin are of sufficient importance to warrant the outlay for apparatus. The numbers of rats on shipboard and the amount of mischief they are capable of are not always appreciated. A French maritime journal is authority for the statement that in May, 1901, after the steamship *Minnehaha* of the Atlantic Transport Company had been disinfected at the London dock by the use of sulphur dioxid over 1,300 dead rats were found in the holds. The vessel had been in commission only about nine months, carrying flour, grain, and provisions between New York and London, and the finding of so many rats was a complete surprise to the ship's officers.

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[a] Circular 46, Bureau of Entomology, U. S. Dept. of Agric., 1907.

MICRO-ORGANISMS.

At irregular intervals when rodents become overabundant, contagious diseases break out and destroy large numbers. Such diseases have been known to occur among ground squirrels, prairie dogs, rabbits, lemmings, house mice, field mice, and rats. They occur also, occasionally, where numbers of the animals are brought together in confined quarters. Observations of such epidemics have encouraged bacteriologists to experiment in inducing diseases artificially for the purpose of destroying rodent pests.

The problem of the bacteriologist is to find an organism that will destroy a given species by contagious disease, and yet be harmless to all other animals, whether wild or domesticated. From a scientific standpoint some progress has been made toward the solution of such problems, but practical results are still lacking. The rat has been the subject of more experiments than any other animal, but attempts to destroy it by epidemics have not yet advanced beyond the experimental stage.

Several micro-organisms, or bacteria, have been exploited in Europe and America for destroying rats. A number are on the market in the United States. The Biological Survey has made laboratory and field experiments with some of them, and has also received many reports from others who have tried the cultures in a practical way. The results are by no means uniform, although the majority are negative. The cultures tested by the Survey have given poor results.

The chief defects to be overcome before the cultures can be recommended for general use are—

1. The virulence is not great enough to kill a sufficiently high percentage of rats that eat food containing the micro-organisms.
2. The virulence decreases with the age of the cultures. They deteriorate in warm weather and in bright sunlight.
3. The diseases resulting from the micro-organisms are not contagious and do not spread by contact of diseased with healthy animals.
4. The comparative cost of the cultures is too great for general use. Since they have no advantages over the common poisons, except that they are harmless to man and other animals, they should be equally cheap; their actual cost is much greater. Moreover, con-

sidering the skill and care necessary in their preparation, it is doubtful if the cost can be greatly reduced.

However, the possibilities in the use of contagious diseases for destroying rats have not been exhausted. It is not improbable that a virulent bacterium, pathogenic for rats and similar rodents only, exists, and that vigilant search will discover it. Bacteriological science is in its infancy and may be expected to make further discoveries of great economic importance. A rat disease, truly contagious, harmless to other animals, and capable of being used at will would be a boon worth many millions of dollars annually to the people of the United States.

ORGANIZED EFFORTS TO DESTROY RATS.

The necessity of cooperation and organization in the work of rat destruction should not be overlooked. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from near-by farms. If, however, the farmers of an entire township or county unite in efforts to get rid of rats, much more lasting results may be attained. Such organized efforts repeated with reasonable frequency are very effective.

Cooperative efforts to destroy rats have taken various forms in different localities. In cities municipal employees have occasionally been set at work hunting rats from their retreats with at least temporary benefit to the community. Thus, in 1904, at Folkestone, England, a town of about 25,000 inhabitants, the corporation employees, helped by dogs, in three days killed 1,645 rats.[a]

Side hunts in which rats are the only animals that count in the contest have sometimes been organized and successfully carried out. At New Burlington, Ohio, a rat hunt took place November 26, 1866, in which each of the two sides killed over 8,000 rats, the beaten party serving a Thanksgiving banquet to the winners.[b]

At about the same period county agricultural societies sometimes offered prizes to the family presenting the largest number of rat tails as evidence that the animals had been destroyed. Even as late as May 2, 1907, in one of the counties of Kentucky, by general consent, the day was set apart for killing rats, and, according to newspaper reports, was quite generally observed.

There is danger that organized rat hunts will be followed by long intervals of indifference and inaction. This may be prevented by offering prizes covering a definite period of effort. Such prizes accomplish more than municipal bounties, because they secure a friendly rivalry which stimulates the contestants to do their utmost to win.

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[a] The Field (London), vol. 104, p. 98, July 16, 1904.

[b] American Naturalist, vol. 26, p. 8, January, 1867.

In England and some of its colonies contests for prizes have been organized to promote the destruction of the European house sparrow, but many of the so-called "sparrow clubs" are really sparrow and rat clubs, for the destruction of both pests are avowed objects of the organization. A sparrow club in Kent, England, secured the destruction of 28,000 sparrows and 16,000 rats in three seasons, by the annual expenditure of but £6 ($29.20) in prize money.[a] Had ordinary bounties been paid for this destruction, the tax on the community would have been about £250 (over $1,200).

AN INTERNATIONAL SOCIETY.

Perhaps the most extensive campaign ever organized against rats is that undertaken by L'Association Internationale pour le Destruction Rationelle des Rats, a society which originated in Denmark and was organized through the influence of a civil engineer named Emil Zuschlag. The purposes of the society are to spread information concerning the mischief done by rats and to carry on a general campaign for their destruction. The influence of the organization has already borne fruit in increased activity in fighting rats in Denmark, Sweden, Saxony, and other countries. In Denmark and Sweden a system of small bounties for killing rats has for several years been in general operation in some of the larger cities, and the Danish Parliament has made appropriations to assist municipalities throughout that Kingdom in paying premiums for the work of destruction. General supervision of the work is in the hands of the society, which receives regular quarterly reports of progress made in the various municipalities. The form of report is shown in Plate III, which is an exact copy of the report for the city of Copenhagen for the last quarter of 1907. The premiums paid are usually small—from 5 to 10 öre (1⅓ to 2⅔ cents) for each rat. Mr. Zuschlag recently reported that under the Danish law appropriating government funds for the prosecution of the society's work, 1,141,293 rats were destroyed during the first year, ending July 1, 1908.[b]

In the city of Copenhagen and its suburbs the campaign began in December, 1899, and 103,000 rats were destroyed during the first eighteen weeks. The premium paid was 10 öre for each rat, but other expenses brought the total cost to about $3,450. The society estimated that during one year 100,000 rats would commit depredations upon property amounting to $97,820; by the work of destruction the city had, therefore, been saved the sum of $94,370.[c] During

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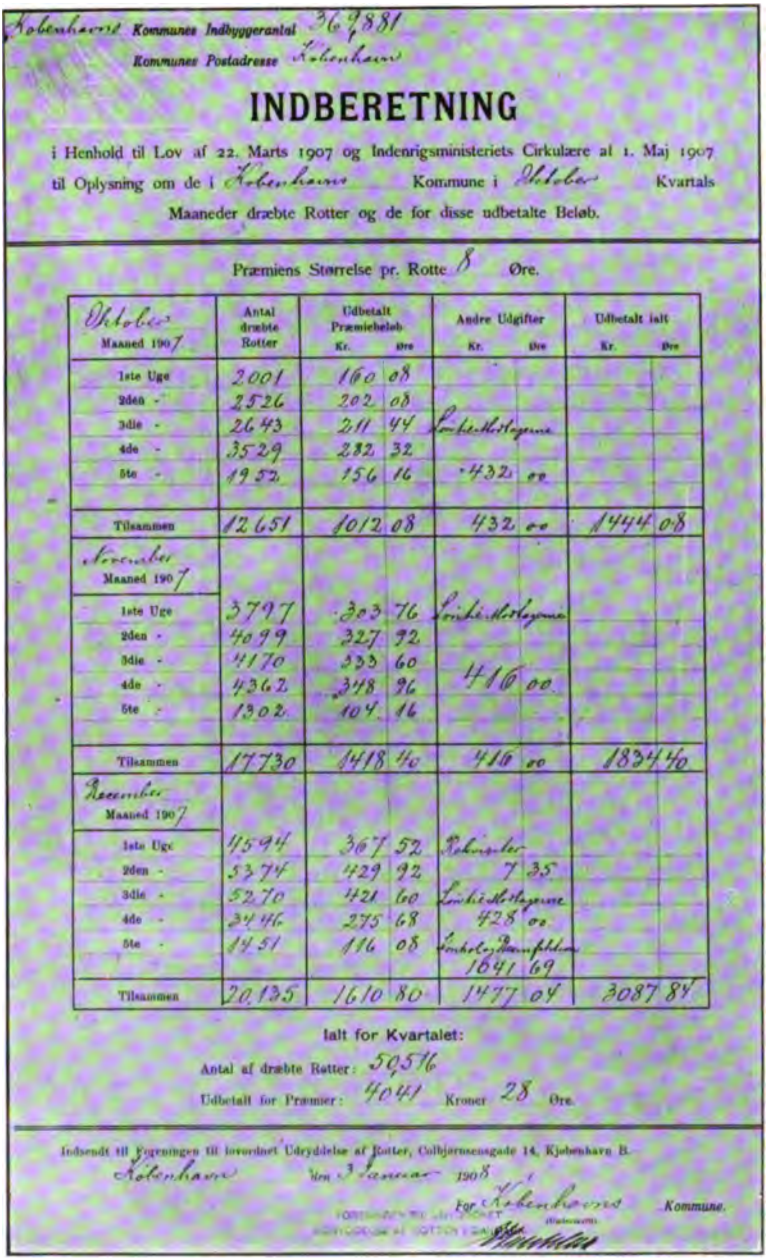
[a] Jour. Board of Agr. Great Britain, vol. 9, p. 342, 1902.

[b] Jour. Inc. Soc. for Dest. Vermin, vol. 1, p. 32, October, 1908.

[c] Le Rat Migratoire, Emil Zuschlag, p. 62, Copenhagen, 1908.



Københavns Kommunes Indbyggerantal 369881
Kommunes Postadresse København

INDBERETNING

i Henhold til Lov af 22. Marts 1907 og Indenrigsministeriets Cirkulære af 1. Maj 1907 til Oplysning om de i København Kommune i Oktober Kvartals Maaneder dræbte Rotter og de for disse udbetalte Beløb.

Præmiens Størrelse pr. Rotte 8 Øre.

Oktober Maaned 1907	Antal dræbte Rotter	Udbetalt Præmiebeløb Kr.	Øre	Andre Udgifter Kr.	Øre	Udbetalt ialt Kr.	Øre
1ste Uge	2001	160	08				
2den -	2526	202	08				
3die -	2643	211	44	[illegible]			
4de -	3529	282	32				
5te -	1952	156	16	432	00		
Tilsammen	12651	1012	08	432	00	1444	08
November Maaned 1907							
1ste Uge	3797	303	76	[illegible]			
2den -	4099	327	92				
3die -	4170	333	60	416	00		
4de -	4362	348	96				
5te -	1302	104	16				
Tilsammen	17730	1418	40	416	00	1834	40
December Maaned 1907							
1ste Uge	4594	367	52	Rekvisiter			
2den -	5374	429	92	7	35		
3die -	5270	421	60	[illegible]			
4de -	3446	275	68	428	00		
5te -	1451	116	08	[illegible] 1641	69		
Tilsammen	20135	1610	80	1477	04	3087	84

Ialt for Kvartalet:
Antal af dræbte Rotter: 50516
Udbetalt for Præmier: 4041 Kroner 28 Øre.

Indsendt til Foreningen til lovordnet Udryddelse af Rotter, Colbjørnsensgade 14, København B.
København den 3 Januar 1908
For Københavns Kommune.
(Underskrift)
FORENINGEN TIL LOVORDNET
UDRYDDELSE AF ROTTER I DANMARK

Copy of Quarterly Report of the Rats Destroyed in Copenhagen, October, November, and December, 1907.

the last two quarters of 1907, in the same city, 83,832 rats were killed. The premiums, 8 öre per rat, amounted to $1,787.36 and the other expenses to $1,198.60, a total of $2,985.96.

In the city of Stockholm, Sweden, the organized work of destroying rats began in February, 1901, and has progressed steadily for the past seven years. The premium paid is 5 öre per rat and the total number of animals upon which the bounty was paid during the first six years follows: 1901 (11 months), 146,191 rats; 1902, 96,443 rats; 1903, 95,348 rats; 1904, 106,263 rats; 1905, 103,233 rats; 1906, 92,037 rats; 1907, 72,282 rats; a total for seven years of 711,797 rats, upon which the premiums amounted to about $9,540. The results here given are hardly encouraging to those who hope for speedy extermination of these pests in large cities. It shows that the animals reproduce almost as rapidly as they are destroyed under the stimulus of a very small premium.

The Danish Society for Rat Extermination has a membership of over 2,000 of the leading citizens of the Kingdom. It has interested and enrolled in its work leading men throughout Europe, and will undoubtedly exert a potent influence for good upon the entire world. As a public policy in America the wisdom of offering bounties for the destruction of noxious animals is open to question, but the Danish society does not confine its work to advocating a single plan for rat destruction. Its chief importance lies in its ability to awaken general interest in the work and to secure cooperation and system in carrying out definite plans.

The influence of the Danish society has been manifested recently in the organization in England of the Incorporated Society for the Destruction of Vermin. The objects of attack are not only rats and mice, but also sparrows, ticks, fleas, mosquitoes, and flies. The immediate activities of the society are to be directed against the brown rat, of which species the society estimates that 40,000,000 exist in the British Islands. The first number of a quarterly periodical devoted to the objects of the society appeared in October, 1908, and considerable interest has already been aroused.

SUMMARY OF RECOMMENDATIONS.

The following are important aids in limiting the numbers of rats and reducing the losses from their depredations:

1. Protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.

2. Greater cleanliness about stables, markets, grocery stores, warehouses, courts, alleys, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.

3. Care in the construction of buildings and drains so as not to provide entrance and retreats for rats, and the permanent closing of all rat holes in old houses and cellars.

4. The early thrashing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.

5. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in the fields.

6. Rat-proofing of warehouses, markets, cribs, stables, and granaries for storage of provisions, seed grain, and feedstuffs.

7. Keeping effective rat dogs, especially in city warehouses.

8. The systematic destruction of rats, whenever and wherever possible, by (*a*) trapping, (*b*) poisoning, and (*c*) organized hunts.

9. The organization of "rat clubs" and other societies for systematic warfare against rats.

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U. S. DEPARTMENT OF AGRICULTURE

BIOLOGICAL SURVEY—BULLETIN No. 34

C. HART MERRIAM, *Chief*

BIRDS OF CALIFORNIA

IN RELATION TO THE FRUIT INDUSTRY

PART II

By F. E. L. BEAL
Assistant, Biological Survey

WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., February 25, 1910.

Sir: I have the honor to transmit herewith for publication as Bulletin No. 34 of the Biological Survey, Part II of the Birds of California in Relation to the Fruit Industry, by Prof. F. E. L. Beal. This, the final part of the report, treats of some of the most important California birds from the standpoint of the orchardist and the farmer. Careful study of the food habits of birds that frequent orchards and their vicinity shows that most of the species are beneficial, and that without their aid the difficulty and expense of raising fruit would be enormously increased; still a few species under certain circumstances are harmful and need to be held in check.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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BIRDS OF CALIFORNIA IN RELATION TO THE FRUIT INDUSTRY—PART II.

INTRODUCTION.

The first part of the report on Birds of California in Relation to the Fruit Industry was published in 1907. In addition to the linnet or house finch, which has attracted wide attention and is the subject of much complaint, 37 other species were discussed. In the present and concluding part, the food habits of 32 additional species are treated. Among them are some of the most important birds of the State, regarded from the standpoint of the farmer and fruit grower. The aim has been to collect all data possible on the food of the several species, to consider the facts impartially, and to render a just verdict as to the birds' economic relations.

All the birds whose food habits are discussed have direct relations with husbandry. It is true that many of them have not been charged with the destruction or injury of fruit or any other farm products. Almost all, however, destroy great numbers of harmful insects or devour seeds of noxious weeds; hence they are important economically.

A large part of the present report consists of statements concerning the food actually found in the stomachs of the birds. In this connection it should be borne in mind that by far the greater number of stomachs used in this investigation were collected in the more thickly settled and highly cultivated parts of the State, so that they probably contain a larger proportion of the products of husbandry than would a series of stomachs taken at random from all parts of the range of each species. It goes without saying that fruit and grain can be eaten only by such birds as have access to those products, while birds living in uncultivated places must subsist upon the fruits of nature.

Some California birds show a marked preference for oats, but in this State the presence of oats in a bird's stomach does not necessarily indicate that cultivated oats have been eaten, for wild oats cover hundreds of thousands of acres, and in the cultivated areas grow almost everywhere, affording a supply of food for many birds. Besides wild oats, the crop of volunteer oats that succeeds the cultivated crop is abundant and is to be found wherever this grain is grown. In fact, in California the eating of oats can not as a rule be counted against a bird.

In no State in the Union is an accurate knowledge of the relations of birds to agriculture more important than in California. Climate and soil combine to make California an important grain and fruit producing State. The acreage already devoted to agriculture is large and is likely to increase for decades to come, as population increases and as new cultural methods are developed and irrigation is extended. Insects that now attract little attention are likely to increase and become serious pests. Certain birds formerly accustomed to a diet consisting partly of wild fruits, the supply of which is limited and likely to become smaller, will probably invade orchards and injure cultivated fruit. Hence it is worth while for the farmer and orchardist to learn as much as possible of the food of the birds that harbor near his premises, that he may know how much good each species does and how much harm, and so be enabled to strike a fair balance.

Some birds, like the swallows, swifts, wrens, and chickadees, are so strictly insectivorous that they are exceedingly beneficial. All they require at the hands of man in return for their services is protection. Others at some time of the year injure crops, though the damage by many is exceedingly small. Be the loss what it may, however, if a given species by its insectivorous habits prevents much greater destruction than it inflicts, the farmer should be willing to bear the loss for the sake of the greater gain.

Few birds are always and everywhere so seriously destructive that their extermination can be urged on sound economic principles. Only four of the species common in California can be regarded as of doubtful utility: These are the linnet, California jay, Steller jay, and redbreasted sapsucker. When the known methods of protecting fruit have been exhausted, or can not be employed profitably, then a reasonable reduction of the numbers of the offending birds is permissible. But the more the food habits of birds are studied the more evident is the fact that with a normal distribution of species and a fair supply of natural food, the damage to agricultural products by birds is small compared with the benefit.

A reasonable way of viewing the relation of birds to the farmer is to consider birds as servants, employed to destroy weeds and insects. In return for this service they should be protected, and such as need it should receive a fair equivalent in the shape of fruit and small grain. Nothing can be more certain than that, except in a few cases, any farmer who is willing to pay the toll collected by birds for actual services rendered will be vastly benefited. In the long run, no part of the capital invested in farm or orchard is more certain to pay big interest than the small sum required for the care and protection of birds.

CALIFORNIA QUAIL.

(*Lophortyx californicus* and *vallicola.*)

The California quail (see frontispiece) is common and generally distributed over the State west of the Sierra, except at the higher altitudes, and is especially abundant in the fruit-raising sections. Like the bobwhite of the East, this quail never goes far from cover, and it delights to dwell on unimproved land where trees and chaparral alternate with small areas of open ground. In settled regions it is somewhat domestic in habits and soon becomes accustomed to living in orchards, gardens, and cultivated grounds. The writer has seen a female sitting upon her eggs in a garden within 30 feet of a house, between which and the nest carriages and foot passengers passed many times each day. In winter a covey frequently feeds with the farmer's chickens, and if not disturbed will continue to do so until pairing time.

The natural food of the quail consists of the seeds of that vast group of plants known as weeds, with a little foliage of the same, especially in winter, when the leaves are young and tender. Considering how small is the amount of fruit usually found in the stomach of this bird, it is a surprise to learn that it sometimes does serious damage to vineyards. Investigation, however, shows that, as in most other similar cases, the injury results only when too many birds gather in a limited area. Nearly all the complaints against the quail for eating fruit are that it visits vineyards in immense numbers and eats grapes. When thousands visit a vineyard, even if only occasionally, and each bird eats or spoils at least one grape, the result is disastrous.

Mrs. Florence Merriam Bailey, writing of the foothills of San Diego County, says:

> In 1889 quail were so numerous that the dust of the roads was printed with their tracks, and it was an everyday matter to have them start out of the brush and run ahead of the horses quite unconcernedly, pattering along in their stiff, prim way, with their topknots thrown forward over their beaks. In fact, the quail were so abundant as to be a pest. For several years great flocks of them came down the canyons to Major Merriam's vineyard, where they destroyed annually from 20 to 30 tons of fruit. In one season, July to October, 1891, 130 dozen were trapped on his ranch. The result of this wholesale destruction was manifest when I returned to the valley in 1894. The birds were then rarely seen on the roads and seldom flushed in riding about the valley.[a]

Another observer states that he once saw a flock of about a thousand quail eating Zinfandel grapes in a vineyard in the central part of the State, and another says that in southern California he has seen as many as 5,000 feeding upon Muscat grapes. In the writer's interviews with California fruit growers, only one mentioned the quail as harmful. His ranch was situated along the hills on the side of a narrow valley, adjacent to wild grazing land with much chaparral and forest, among which the quail lived. In this case the annual loss was estimated at 2 or 3 tons of grapes.

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[a] Auk, XIII, p. 116, 1896.

In the laboratory investigation of the food of the California quail 619 stomachs were examined. They were collected in every month except May, but only one was obtained in March. The other months are well represented. Animal food, principally insects, amounts to but 3 percent, and most of this was found in the stomachs of young birds, mere broodlings. Vegetable food amounts to 97 percent and consists mainly of seeds of plants most of which are of noxious or troublesome species.

Animal food.—Ants appear to be a favorite food. They were found in 82 stomachs, and were eaten by adults as well as by young. They amount, however, to less than 1 percent of the whole diet. The rest of the animal food aggregates a little more than 2 percent and is distributed as follows: Beetles in 30 stomachs, bugs (Hemiptera) in 38, caterpillars in 11, grasshoppers in 7, flies in 2, spiders in 6, millepeds in 1, and snails in 2. The most interesting point in this connection was the stomach of a broodling only 3 or 4 days old. Besides several adult Hemiptera, some ants, caterpillars, and spiders, and a few seeds, it contained 280 minute insects, which constituted 76 percent of the stomach's contents, and were identified as an immature form of a species of scale, *Phenacoccus helianthi.*

In this connection the following extract from a letter dated at Los Angeles, Calif., October 28, 1908, by Dr. W. G. Chambers, to the Secretary of Agriculture is interesting:

> Last May during the hatching season one of my female quail died a week prior to completing the hatch. An incandescent light of 8 candlepower was substituted, the result being 15 baby quail, very wild at first, not understanding human sounds or language, but finally becoming as docile as pet chickens. They were raised in my back yard, running at large after the first week.
>
> A number of Marguerite bushes which grow in profusion in the yard were so infested with black scale that I had decided to uproot them and had postponed doing so, as the little quail worked so persistently among the branches; upon investigation I discovered them eating the scale and twittering happily; they would swallow the fully developed scale and thoroughly clean the branches of all those undeveloped.

The young in the first week of life eat animal matter to the extent of from 50 to 75 percent of the food, but by the time they are 4 weeks old they take little if any more animal food than the adults.

Vegetable food.—The vegetable part of the quail's food may be divided into fruit, grain, seeds, and forage. Fruit appeared in 106 stomachs, and aggregates 2.3 percent of the yearly diet. It was distributed as follows: Grapes in 7 stomachs, prunes in 9, apple in 3, Rubus (blackberry or raspberry) in 4, olive in 1, elderberry in 21, snowberry in 8, manzanita in 2, huckleberry in 11, and rose-haws in 3.

Pulp and skins, identified as fruit only, were found in 27 stomachs, and unknown seeds, probably those of some small fruit or berry, occurred in 10 stomachs. It is evident that the percentage of any one of the above is insignificant. Stomach examination throws no new light upon the quail's grape-eating habits, except to show that the ravages complained of are exceptional. That fruit does not constitute any important part of the bird's annual food is clearly proved.

Grain was found in 133 stomachs, and constitutes 6.4 percent of the food. It was distributed as follows: Corn in 14 stomachs, wheat in 15, oats in 13, barley in 89, and rye in 2. The principal complaints against the quail on the score of grain eating are that flocks sometimes visit newly sown fields, and eat large quantities of the seed. Walter E. Bryant says on this point:

> Two males which I shot one evening, as they were going to roost for the night, after having been feeding on a newly sown field, contained the following, mainly in the crop: (*a*) Two hundred and ten whole grains of barley, 6 pieces of broken barley, 3 grains of 'cheat,' and 1 of wheat, besides a few barley hulls, some clover leaves, and alfilaria; (*b*) one hundred and eighty-five whole grains of barley, 5 broken pieces, 4 grains of 'cheat,' and 2 of wheat; also barley hulls, clover, and alfilaria. The flock numbered nearly or quite 20 birds.[a]

Only one report accuses the bird of eating grain from the harvest field. Mr. W. T. Craig, of San Francisco, writing to the United States Department of Agriculture, says:

> I have observed the quail enter a field of wheat to the number of thousands, and had they not been driven away they would have destroyed the whole crop.

Stomach examination does not indicate any month in which grain is eaten in excess of other food. January shows the highest percentage, 12.4, but November is nearly as high, while December, although between the two, shows less than 3 percent. A little more than 3 percent was eaten in February, and none at all in March and April, though the newly sown grain would be accessible in one at least of these months. June and July, the harvest months, show respectively 4.1 percent and 10.7 percent. In fact the stomach record plainly indicates that the quail does not make special search for grain, but being naturally a seed eater takes grain when it comes in the way.

The seeds of a multitude of plants which have no apparent useful function except to increase by their decay the deposit of humus in the soil constitute the staff of life of the quail. In this particular investigation they aggregate 62.5 percent of the food of the year. They appear in stomachs taken in every month and reach a good percentage in each, the only months that show much diminution in quantity being January, February, March, and April, when new forage partly replaces seeds. The percentage is highest in June, 85.9, but shows no great falling off from July to December inclusive.

---

[a] Zoe, IV, pp. 55–56, 1893–94.

Seventy-three kinds of seeds were identified, at least generically, and more than half of them were determined specifically. Many more were ground up so as to be unrecognizable. The following is a list of the seeds with the number of stomachs in which each kind occurred:

Poverty weed (*Iva axillaris*)	3
Gum weed (*Grindelia squarrosa*)	2
Bur marigold (*Bidens* sp.)	17
Sunflower (*Helianthus* sp.)	1
Tarweed (*Madia sativa*)	67
Mayweed (*Anthemis cotula*)	27
Milk thistle (*Silybum marianum*)	14
Thistle (*Cirsium* sp.)	5
Blessed thistle (*Cnicus benedictus*)	1
Bur thistle (*Centaurea melitensis*)	201
Sow thistle (*Sonchus asper*)	2
Sow thistle (*Sonchus oleraceus*)	1
Prickly lettuce (*Lactuca scariola*)	4
California dandelion (*Agoseris* sp.)	2
Blue vervain (*Verbena hastata*)	22
Stickseed (*Echinospermum* sp.)	16
Burweed (*Amsinckia tesselata*)	11
Ribwort (*Plantago lanceolata*)	2
Pursh ribwort (*Plantago purshi*)	1
Common plantain (*Plantago major*)	2
Painted cup (*Castilleia* sp.)	1
Black nightshade (*Solanum nigrum*)	10
Dodder (*Cuscuta* sp.)	3
Morning glory (*Convolvulus* sp.)	2
Pimpernel (*Anagallis* sp.)	2
Carrot (*Daucus carota*)	5
Lupine (*Lupinus* sp.)	150
Bur clover (*Medicago denticulata*)	156
Sweet clover (*Melilotus alba*)	6
Clover (*Trifolium* sp.)	75
Deer weed (*Lotus glaber*)	50
Vetch (*Vicia* sp.)	32
Five-finger (*Potentilla* sp.)	1
Turkey mullein (*Eremocarpus setigerus*)	168
Sumac (*Rhus laurina*)	69
Poison oak (*Rhus diversiloba*)	52
Alfilaria (*Erodium cicutarium*)	30
Alfilaria (*Erodium moschatum*)	
Carolina geranium (*Geranium carolinianum*)	47
Common geranium (*Geranium dissectum*)	
Wood sorrel (*Oxalis corniculata*)	1
Mallow (*Malva rotundifolia*)	11
Shepherd's purse (*Capsella bursapastoris*)	1
Peppergrass (*Lepidium* sp.)	5
Wild radish (*Raphanus sativus*)	5
Black mustard (*Brassica nigra*)	32
Wild turnip (*Brassica campestris*)	3
California poppy (*Eschscholtzia californica*)	1
Buttercup (*Ranunculus* sp.)	14

Water crowfoot (*Ranunculus aquatilis*)	3
Miner's lettuce (*Montia perfoliata*)	26
Red maids (*Calandrinia menziesi*)	58
Pigweed (*Chenopodium album*)	11
Rough pigweed (*Amaranthus retroflexus*)	77
Corn spurry (*Spergula arvensis*)	1
Common chickweed (*Stellaria media*)	62
Field chickweed (*Cerastium arvense*)	2
Sleepy catchfly (*Silene antirrhina*)	58
Black bindweed (*Polygonum convolvulus*)	1
Dotted smartweed (*Polygonum punctatum*)	2
Common knotweed (*Polygonum lapathifolium*)	2
Wire grass (*Polygonum aviculare*)	55
Curly dock (*Rumex crispus*)	9
Sorrel (*Rumex acetosella*)	59
Sedge (*Carex* sp.)	26
Galingale (*Cyperus* sp.)	7
Rag grass (*Lolium perenne*)	56
Soft brome (*Bromus hordeaceus*)	3
Cheat, or chess (*Bromus secalinus*)	18
Walk grass (*Poa annua*)	29
Timothy (*Phleum pratense*)	1
Bear grass (*Stipa setigera*)	5
Canary grass (*Phalaris caroliniana*)	2
Unidentified seeds, mostly ground up	293

From this list it would appear that bur thistle, lupines, bur clover, and turkey mullein are the favorite seeds; that the others are not distasteful is shown by the quantities found in some stomachs. For instance, mayweed was identified in only 27 stomachs, yet one stomach contained at least 2,000 of these seeds; pigweed (*Chenopodium*) in but 11, yet one contained 1,000. One stomach held 83 kernels of barley, 592 seeds of geranium, 560 of tarweed, 40 of bur thistle, 48 of clover, 80 of alfilaria, 704 of timothy, 32 of catchfly, and 5 of snowberry, or 2,144 seeds in all. Another contained 1,696 geranium seeds, 14 bur thistle, 24 knotweed, 14 tarweed, 38 bur clover, 148 alfilaria, 12 ray grass, and 1 unknown seed, and a pod of uncertain origin—in all 1,944 seeds and a pod. In both cases the contents of the crop is included with that of the stomach or gizzard. These samples indicate considerable variety in the quail's diet, even in one meal.

Grass and other forage constitute a little over 25 percent of the quail's annual food. Forage amounts to less than 1 percent in June, remains about the same until October, and increases somewhat in November. In January it becomes important, and it reaches nearly 60 percent of the food for the next four months. The maximum, 85 percent, occurs in March; but this percentage, based on only one stomach, can not be considered final. Seeds and forage are practically complementary to each other—that is, as one increases the other decreases. June, which shows the least forage, has the largest percentage of seeds. Leaves of red and of bur clover and of alfilaria were the favorite kinds, and in some cases constituted the whole stomach contents. Blades of grass are frequently taken. A few bits of acorn, and perhaps other nuts, were eaten, but the quantity is insignificant.

SUMMARY.

From the above analysis of the food of the California quail, it is apparent that under normal conditions the farmer and fruit grower have nothing to fear from its ravages. When, however, large areas of chaparral land are cleared and brought under cultivation, it is natural that the products of garden and vineyard should be eaten to a greater or less extent by quail, which abound in such localities. On the other hand, its seed-eating record is greatly in its favor. Usually there is little difficulty in getting rid of a superfluity of game birds; in fact, in most cases the trouble is to prevent their extermination. A bird so large, so easily trapped, so valuable as food, and withal one whose pursuit affords such excellent sport as the valley quail, will probably not become numerous enough to do serious damage except locally and under unusual conditions, and then a reduction of numbers is the easiest and simplest cure. Permits to trap quail on one's own premises are obtainable in California on application to the State fish commissioner. After the birds have been sufficiently reduced, they can be kept within reasonable limits by a moderate amount of shooting in the proper season.

WOODPECKER FAMILY.

(Picidæ.)

Among the useful birds of the State few take higher rank than the woodpeckers. They are mainly arboreal, and most of them may be designated as conservators of the forest in the strictest sense. The larvæ of certain species of beetles and moths live either under the bark or within the solid wood of trees, where they are safe from the attacks of birds, except such as are furnished by nature with special tools for digging into wood and bark. In this respect our native woodpeckers are in general highly favored. The peculiar structure of their chisel-shaped beak, combined with sharp claws and a stiffened tail for support, enables them, when they have located their prey, to drill down to it through several inches of wood and draw it forth with their tongue. This latter organ, in the more typical species of the family, is long, cylindrical, and barbed at the tip, being particularly well adapted for probing the burrows of boring insects.

Twenty-one species and subspecies of woodpeckers occur in California. Of these about half a dozen are sufficiently abundant and widely distributed to be economically important. The average amount of insect food in the stomachs of the six species discussed in the following pages is 62 percent of the whole contents.

It is unfortunate that the most valuable species of our woodpeckers are not abundant. In many parts of the country the downy and hairy woodpeckers are quite rare and, what is worse, appear to be diminishing in numbers. As they are among the most valuable of our species, it is worth while to inquire into the cause of their scarcity and if possible to devise efficient remedies. In most sections these birds can obtain an abundance of food, and as they are not persecuted, so far as known, the most probable cause for their scarcity would appear to be the lack of suitable nesting sites. This is especially true in the northeastern part of the United States where the war waged upon the gipsy and brown-tail moths has led to the trimming of all dead trunks and limbs from forests and orchards, so that the woodpeckers, which as a rule dig new nesting holes every year, are left with no places in which to nest. In Germany, after much experimentation, it has been found possible to construct nesting boxes which the European woodpeckers freely use. There can be no reasonable doubt that a similar result can be attained in this country. Pending experiments and as a step in the right direction, it would be well for orchardists to leave the stubs of dead limbs on orchard trees as sites for the nests of woodpeckers. While the woodpecker may use the nest it excavates only one season, the hole will be available for bluebirds, wrens, chickadees, and nuthatches in succeeding years. The experiment of inducing our woodpeckers, especially the downy and hairy, to build in artificially constructed nesting boxes is well worth patient and persistent experiment.

HAIRY WOODPECKER.

(*Dryobates villosus harrisi* and *hyloscopus*.)

Two subspecies of the hairy woodpecker occur in California, and between them they occupy nearly the whole State at some time of the year. Their favorite haunts are open groves and orchards, and as forests disappear and fruit trees increase in number, they will probably more and more inhabit orchards. That the hairy woodpecker is far from abundant at present is unfortunate, for its food habits make it of great economic importance. Only 27 stomachs have been examined, but the dates of collection are well distributed. Seven is the greatest number taken in any one month (September), and none at all were obtained in March, May, August, and October. While this number is sufficient to afford a general idea of the kind of food the bird prefers, it does not furnish reliable data as to the relative proportions of the different constituents.

Of the contents of the 27 stomachs, 78 percent consisted of animal matter, nearly all of which was either insects or spiders. The remaining 22 percent was made up of various vegetable substances. In the relative proportions of animal and vegetable food the California bird differs somewhat from the eastern subspecies, the diet of which consists of 68 percent of animal matter to 32 of vegetable.

Animal food.—Of the various items in the food of the western hairy woodpecker, the most important, as well as the largest, is the larvæ of wood-boring beetles (Cerambycidæ and Buprestidæ). These aggregate for the year nearly 49 percent of the total. This is a much greater proportion than is eaten by the eastern subspecies, and is probably not exceeded by any other bird. Each of several stomachs contained more than 20 larvæ. When the immense damage done by these borers to forest trees, as well as to orchards, is considered, it is hardly possible to overestimate the value of this woodpecker's services. Moreover, these insects are concealed and protected from the attacks of all birds except those of this family. Most of these insects are taken in the cooler months, the fewest being eaten in July. One stomach taken in February contained 70 percent of wood-borers, and the remainder, or 30 percent, consisted of other harmful beetles. Two stomachs taken in April contained an average of 76 percent of these destructive borers and 6 percent of other beetles. Beetles belonging to various families, nearly all of them harmful, and some very injurious, amount to over 9 percent of the food.

Ants are usually a favorite article of food with woodpeckers, but with the California hairy woodpeckers they constitute less than 3 percent of the year's food. This is somewhat surprising, as the eastern bird eats them to the extent of 17 percent. Other Hymenoptera, including wasps, amount to less than 2 percent.

Caterpillars exceed 11 percent, and stand next to beetles in importance. Many of them are of wood-boring species and evidently were dug out of trees.

A few miscellaneous insects and some spiders complete the animal food. Several stomachs contained segments of millepeds, or thousand legs, and one held the remains of one of those bristly creatures known as jointed spiders (Solpugidæ).

Vegetable food.—The vegetable part of the diet may be divided into fruit, seeds, and miscellaneous substances. Fruit amounts to 6 percent, and consists of the smaller kinds, probably mostly wild species. Rubus seeds (raspberry or blackberry), found in several stomachs, were the only fruits positively identified. Seeds aggregate nearly 12 percent, and all that were determined belonged to coniferous trees. The miscellaneous part contains a little mast and some cambium, or inner bark, but is mostly rubbish, such as rotten wood, probably swallowed accidentally with the beetle larvæ.

SUMMARY.

The above brief review of the food of the hairy woodpecker indicates that nearly half its yearly food consists of larvæ of some of the most destructive insects known, while this service is not offset by the destruction of any useful product. The other elements of the bird's food are either beneficial or neutral. It is unfortunate that the species is not more abundant on the Pacific coast.

DOWNY WOODPECKER.

(*Dryobates pubescens gairdneri* and other subspecies.)

To the ordinary observer the downy woodpecker is only a miniature edition of the hairy, which it resembles in everything but size. It seems, however, to be far more abundant than its larger relative, especially in California. It is much more domestic than the hairy, and frequents orchards and gardens and the vicinity of houses. Its food consists of the same elements but in different proportions. The following report is based on an examination of 80 stomachs, taken in every month of the year. The food consists of 77 percent of animal matter to 23 of vegetable, thus agreeing closely with the diet of the hairy.

Animal food.—The animal food is composed of insects, with a few spiders. The western downy eats 16 percent of wood-boring larvæ, a little more than the eastern downy, but less than one-third as much as the hairy woodpecker. Other beetles amount to 13 percent. They are mostly harmful species, the exception being a few Carabidæ, or predaceous ground beetles.

Ants are eaten to the extent of 12 percent, which is less than half the quantity taken by the eastern subspecies. While ants may sometimes subserve a useful purpose, they are for the most part annoying or noxious. It is well known that they protect and foster plant lice, and they often injure timber by boring galleries through it, frequently beginning in the abandoned burrow of a beetle larva. In houses they are an unmitigated nuisance, and in gardens and lawns are often equally obnoxious. For these reasons the habitual destruction of ants by woodpeckers is commendable. Other Hymenoptera amount to less than 2 percent, and consist of wasps and wild bees.

The largest item in the food of the downy is made up of caterpillars, pupæ, and a few adult moths. These aggregate a little over 21 percent. Pupæ of the codling moth were identified in 4 stomachs and the larvæ in 2, of which one contained 16 entire full-grown larvæ. Another held the remains of 20 of these pernicious insects. From investigations during the past few years it appears that birds constitute a most efficient natural check to the spread of this destructive moth, especially such birds as woodpeckers, titmice, nuthatches, and creepers, which obtain much of their food from crevices in the bark of trees. It behooves the orchardist to see that these birds are carefully protected on his premises and encouraged in every possible way.

The Hemiptera, or bugs, which appear in the food of the downy woodpecker are plant lice and scales, with a few other forms. They amount to 10 percent of the year's food, but all were eaten in the seven months beginning with March, and averaged 17 percent for each of these months. Scales were found in 8 stomachs, and in one they constituted 83 percent of the contents. The black olive scale (*Saissetia oleæ*) was the only one identified. Plant lice were found in 11 stomachs, but none were specifically identified, although some were of the woolly species. That these are a favorite food is shown by the quantity eaten. Five stomachs contained the following percentages: 94, 94, 84, 81, and 80. These creatures are so fragile that the process of digestion soon destroys their shape, and it is highly probable that small numbers were contained in many more stomachs but were not identified.

Grasshoppers, although a favorite article of bird food, are entirely ignored by the downy woodpecker. This emphasizes the arboreal habits of this species, as most birds feed upon grasshoppers, when in season, in preference to their ordinary food. Flies also are practically absent from the diet of the downy. A few miscellaneous insects and spiders, amounting in all to 3 percent, make up the remainder of the animal food.

Vegetable food.—The vegetable part of the food may be arranged under three heads—fruit, seeds, and miscellaneous items. Fruit was found in 14 stomachs, and amounts to 9 percent of the food. Cherries were identified in a few stomachs, and apples, or a similar fruit, in several more; but most of the remains were skins of small berries not further identified. Evidently this bird does little or no damage to fruit. Seeds amount to a little more than 7 percent, and are mostly those of poison oak, which the downy, in common with many other birds, aids in disseminating. Grain (oats) was found in 2 stomachs. The miscellaneous vegetable food, 7 percent, consists of mast, or acorn meat, a little cambium, and rubbish.

Food of young.—A nest of young downies was watched for 12 one-hour periods during six days, and the number of feedings noted as follows:

Date.	Hours in forenoon.	Number of feedings.	Hours in afternoon.	Number of feedings.
June 7	9.16–10.16	12	4.23–5.23	13
June 8	8.01– 9.01	10	1.13–2.13	10
June 9	10.42–11.42	12	5.00–6.00	10
June 10	9.17–10.17	14	2.34–3.34	10
June 11	10.15–11.15	11	4.49–5.49	15
June 12	10.37–11.37	20	4.33–5.33	23

In the twelve hours during which the birds were watched, the nestlings were fed 160 times, an average of 13⅓ times per hour; or each of the 4 was fed more than three times per hour. The nest was in a stub of a cherry tree in a mixed orchard, and apparently all the foraging was done in the immediate vicinity, as food was brought too often to have been carried any great distance; moreover, the parent birds were frequently seen searching the trees. Both parents took part in caring for the young, one often waiting patiently near by while the other fed the nestlings. At first the parent birds entered the nest chamber when they came with food, but later, as the nestlings grew larger, they remained outside, thrusting their heads in at the opening. The food nearly always appeared as a white mass in the beak, which led to the suspicion that the young were being fed with woolly aphids. The parent birds came from the direction of a number of apple trees which were badly infested with this pest, and the bark of the trees showed places from which the insects had been recently taken. Thus it was practically certain that aphids were being fed to the young woodpeckers.

SUMMARY.

From the foregoing account it is evident that the downy woodpecker is of great value to the horticulturist. Its food consists largely of orchard pests, and its levies upon fruit are insignificant. The orchardist should note that the downy makes its nest in a chamber which it excavates in a partly rotten trunk or limb of moderate size, frequently of an apple tree. Where such wood occurs in or about the orchard, it should be left for the convenience of the woodpecker and his successors, the wrens and titmice. By so simple a precaution as this the number of downies and of other useful birds that build in holes may be materially increased in an orchard and their services secured without cost at the very point where most needed. When trimming dead limbs, it is necessary only to leave a few inches of the stub, which is not unsightly, and which answers all the purposes of the woodpecker.

NUTTALL WOODPECKER.

(*Dryobates nuttalli.*)

The Nuttall woodpecker is well distributed over California west of the Sierra Nevada, but is less abundant than the downy and not quite so domestic. It is rather more fond of big oaks and other forest trees than of the orchard, but is often found on fruit trees.

The following analysis of its food is based upon the examination of the contents of 46 stomachs, taken in various parts of the State and in every month except May. The first division of the food into animal and vegetable matter gives 78 percent of the former to 22 percent of the latter, exactly the same as in the case of the hairy woodpecker.

Animal food.—Of the animal food, beetles are the largest item, and amount to nearly 34 percent. They consist largely of larval Cerambycidæ, or borers. While not so good a driller for insects as the hairy, the efforts of the Nuttall are not to be despised. It destroys a goodly number of wood-borers, but it eats more adult beetles of other families than do either of the species whose food has been discussed. A considerable number of small leaf beetles (Chrysomelidæ) are eaten by the Nuttall, and are probably taken from leaves. It eats also click beetles (Elateridæ), darkling beetles (Tenebrionidæ), and weevils (Rhyncophora), among which the genus *Balaninus*, that preys upon acorns and other nuts, was identified. A few predaceous ground beetles (Carabidæ) were found.

Ants do not appear to be a favorite food of this woodpecker, and they were eaten very irregularly. They constituted 36 percent of the food in June, 22 percent in September, and appear in small quantities in January and August, but are completely wanting in the other months. The average for the year is less than 6 percent. Other Hymenoptera form practically the same percentage, but nearly all were contained in a single stomach taken in December.

Hemiptera (bugs), like ants, are taken very irregularly and occur either in considerable quantities or not at all. In January they amount to 46 percent of the food of the month, in February to 28 percent, in June to 10 percent, in July to 36 percent, but in the other months do not appear. The average for the year is 11 percent. They belong to several families, but no special pest is prominent. Scales were found in two stomachs and plant lice in one. Three stomachs contained remains of the box-elder bug, *Leptocoris trivittatus*, of which two stomachs contained between 30 and 40 specimens each. This bug is very abundant in some places at times, and injures the box-elder tree. It has also done some damage to fruit.

Diptera (flies) were found only in the stomachs taken in June. They amounted to 12 percent for that month or 1 percent for the whole year.

Caterpillars stand next to beetles in the quantity eaten by the Nuttall woodpecker. They amount to over 13 percent of the food, and, except in the three winter months, appear very regularly. Many of them are of the wood-boring kinds, but leaf-eaters also are present. Various other insects, insects' eggs, and a few spiders amount to 7 percent, and complete the animal food.

Vegetable food.—Fruit amounts to 11 percent, or half of the vegetable food. Naturally most of it was taken during the summer and fall months, although the one stomach taken in December contained

35 percent of fruit pulp not further identified. The greater part of the fruit eaten is of wild species, of which the elder (*Sambucus*) is the favorite. Rubus fruits (raspberry or blackberry) were found in a few stomachs. Probably this bird will never do any serious harm by eating fruit. Seeds of poison oak, cambium, and mast (acorns) make up the other 11 percent of the vegetable food, and have no special economic interest, except that the scattering abroad of the seeds of poison oak is a nuisance. Taken as a whole, the vegetable food of the Nuttall is of little economic importance.

SUMMARY.

While the evidence at hand does not show that this bird feeds on any specific pest, yet it is doing good in preying upon noxious insects in general; moreover, it does not injure any product of husbandry. It should therefore be encouraged to pursue its good work.

RED-BREASTED SAPSUCKER.

(*Sphyrapicus ruber.*)

While the red-breasted sapsucker inhabits most of California at some time of the year, it is generally absent from the valleys during the warmer months, usually retiring to the mountains and forest regions to breed.

Of the 24 stomachs of this species received, nearly all were taken in fruit-growing sections, and represent only the months from September to March inclusive. Statements based upon the examination of so little material can scarcely be considered final, but considerable knowledge may be gained of the kinds of food eaten, even if the relative quantities can not be determined. The food consists of 63 percent of animal matter and 37 percent of vegetable.

Animal food.—Seventy-five percent of the animal food consists of ants, and the average per month is 40 percent of the whole diet. Two stomachs taken in January contained an average of 49 percent each. One stomach collected in March held 84 percent, and one in September was completely filled with them. In other months the amounts were less. In respect to ant eating this sapsucker keeps up the reputation of the family. Other Hymenoptera aggregate only a little more than 7 percent, and all were found in stomachs taken from October to December inclusive.

This bird, like its eastern relative, has the habit of removing patches of bark from certain live trees, usually willows, for the sake of cambium and of the sap which exudes; and it also eats the insects attracted by the sap, which are mostly bees, wasps, and ants; probably this accounts for the large predominance of Hymenoptera in the sapsucker's diet.

Beetles amounted in January to 3.5 percent, in November to 1.4 percent, in December to 0.7 percent, with none at all in the other months. The average for the whole year is only 0.8 percent. No larvæ of wood-borers were found, and apparently this bird never aids the hairy woodpecker in the good work of destroying these creatures. The species eaten were mostly small leaf beetles (Chrysomelidæ), with a few weevils.

Hemiptera (bugs) and Diptera (flies) were entirely wanting in the stomachs examined. Caterpillars were present in two stomachs, both taken in October. They amounted to 5 percent of the food of that month. One stomach taken in February was entirely filled by a large centipede.

Vegetable food.—The vegetable part of the food of the red-breasted sapsucker falls naturally into three divisions—fruit, seeds, and other vegetable matter. As the bird is not present in the fruit-growing sections of the State when fruit is ripe, it can not make great inroads upon the orchard. While fruit aggregates nearly 17 percent, it is mostly wild or of worthless varieties. Figs, whose seeds and pulp were found in one stomach, were the only cultivated kind identified. Several stomachs contained berries of the pepper tree (*Schinus molle*), one contained cascara berries (*Rhamnus californicus*), and in several were unidentified seeds and pulp. Seeds amount to about 9 percent, and are those of the poison oak, with a few others. The miscellaneous item is made up almost entirely of cambium, or the inner bark of trees, and amounts to about 11 percent of the whole food.

SUMMARY.

It is evident that the red-breasted sapsucker falls far below some other members of its family in economic importance. It does not prey upon the worst pests of the orchard and forest, but on the other hand it does not feed on the products of the orchard or farm. It injures trees by tapping holes in the bark and by stripping it off in patches, for which reason this sapsucker may be considered more harmful than beneficial.

CALIFORNIA WOODPECKER.

(*Melanerpes formicivorus bairdi.*)

The California woodpecker is distributed throughout a large part of the State, but is in the main confined to places where there is an abundance of large oaks—trees for which it appears to have a special liking and from which it derives much of its subsistence. Wherever it lives it is usually abundant and the most noticeable element of the bird fauna, attracting attention both by its loud cries and by its conspicuous flight. It is one of the few woodpeckers whose food is more largely vegetable than animal.

Of all the woodpeckers the California has made most impression on nonscientific observers, owing to its peculiar habit of drilling holes into the trunks and branches of dead trees or into the bark of living ones, in each of which it stores an acorn. Wherever the bird is abundant every dead trunk or large branch is punctured with holes, frequently less than an inch apart. So zealous is it in this work that when trees are not available it often drills holes in cornices, church spires, telegraph and telephone poles, and fence posts. The woodpecker does not get the benefit of all its hoarded acorns by any means, for jays, rats, mice, and squirrels have learned where they can obtain food in winter, and are not backward in helping themselves to the woodpecker's stores. As this robbery of his larder is resented by the owner, it leads to endless quarrels.

For the laboratory investigation of the food of the California woodpecker 75 stomachs were available. They were taken in every month except February, April, and May, the greater number in June and July, when the bird's chances to do mischief are greatest. The food consists of 22.43 percent of animal matter to 77.57 percent of vegetable. This is the highest percentage of vegetable matter yet found in the stomach of any woodpecker, though the red-bellied (*Centurus carolinus*) comes very close to it.

Animal food.—Beetles constitute the smallest item of the animal food. They amount to less than 3 percent, and are distributed among several families. The only month in which they are at all prominent is July, when they reach nearly 15 percent. No wood-boring larvæ were found. This would seem to indicate that the bird uses its chisel-shaped bill solely for the purpose of boring holes in which to store acorns, instead of excavating for insects.

Ants amount to 8.21 percent of the food. In one stomach taken in March they constitute 50 percent of the contents, but in no other do they reach 11 percent. The specific name of this bird, *formicivorus*, ant-eating, is not well chosen, for ants do not form a large part of its diet as compared with several other woodpeckers. Other Hymenoptera amount to 6.88 percent. More than half of these were in stomachs taken in August, when they aggregate 33 percent.

A few bugs, flies, and grasshoppers, with fragments of caterpillars, make up the remainder of the animal food, 4.52 percent. One stomach contained a few black olive scales.

Vegetable food.—Grain, fruit, and mast constitute nearly the whole of the vegetable food. One stomach taken in January contained nothing but corn, and another in December contained a few corn hulls. This is the whole of the grain record, and is of no economic interest. The average for the year but slightly exceeds 1 percent. Fruit amounts to a little more than 24 percent, and was found in nearly every month in which stomachs were taken. Most of it was evidently the pulp of the larger cultivated varieties, though that in the stomachs taken in winter could have had no economic value. Seeds of the elderberry (*Sambucus*) were found in two stomachs. The largest amounts of fruit were eaten in August and September, when they reached 59.34 and 54 percent, respectively. While this is a high percentage of fruit, it is not believed that the bird does any sensible damage in the orchard, since it is not numerous enough and does not usually frequent cultivated ground. No complaints of such damage have yet been heard.

The principal item of food of the California woodpecker is acorns. Acorns form 52.45 percent of the year's food, and were found in every month when stomachs were taken except August; as only three were collected in that month, the record is not very reliable. In November, when 12 stomachs were taken, mast amounted to nearly 93.58 percent of the average contents. In 12 stomachs collected in June, when fruit and insects are abundant, it averaged 79.25 percent. In July it fell to 29.47 percent, the deficiency of acorns being made up by animal food, which attains the highest percentage in that month. The question has been raised whether the woodpecker stores acorns for the sake of the meat, or for the grubs that frequently develop therein. Stomach examination shows that, while the substance of the acorn is eaten freely whenever obtainable, larvæ are almost entirely wanting. It is therefore the nuts themselves that the woodpecker stores for food. From an economic point of view little objection to this acorn-eating habit can be raised. The acorn crop is usually superabundant, and in most cases can not be put to better use than to tide the woodpeckers over the winter until insects become plentiful.

SUMMARY.

From the foregoing discussion of the food of the California woodpecker it is obvious that the bird's food does not possess high economic value. On the other hand the bird can not be charged with the destruction of useful insects or of any product of husbandry. While it eats some fruit, it does not habitually infest orchards, and is seldom numerous enough to be a serious nuisance. The few insects it eats are nearly all harmful.

The trees used by the bird for storehouses are usually dead or partly so, and in living trees the punctures do not go through the bark, so that no harm is done. When holes are drilled in buildings, fences, or telegraph poles, the injury is real, but on the whole the damage done in this way is not extensive.

When the beneficial and injurious habits of the bird are carefully weighed, the balance is decidedly in the bird's favor; and from the esthetic standpoint few birds are more interesting and beautiful.

RED-SHAFTED FLICKER.

(*Colaptes cafer collaris.*)

In food habits the flickers of California do not differ essentially from their eastern relatives. They are usually abundant wherever there are trees, and are frequenters of orchards, though they usually choose higher trees for nesting sites. They are among the most terrestrial of the woodpeckers, and obtain a large part of their food on the ground.

For the investigation of the flicker's food 118 stomachs, taken in all months except January and May, were available. In these stomachs animal food amounts to 54 percent and vegetable to 46 percent.

Animal food.—Beetles, in either adult or larval form, do not appear to be favorite food with the flicker. They amount to 3 percent of its diet, and are apparently eaten to a small extent in every month. In August they amount to 8 percent, in November to 7, and in all other months the percentage is small. They belong to 6 families, all harmful except the predaceous ground beetles (Carabidæ). These occurred in 33 stomachs, but the percentage in each case was small, and they seem to be taken only incidentally. Weevils were found in 4 stomachs, click beetles in one, darkling beetles in 6, rove beetles in 3, and *Notoxus alamedæ* in one.

Ants constitute the largest item of the flicker's food, and are eaten in every month. They are the object of the bird's search on the ground and in rotten logs and stumps. The average for the year is 45 percent, the same as was found in 230 stomachs of the eastern flicker. The stomach and crop of one individual of the eastern form taken in Texas was filled with over 5,000 small black ants (*Cremastogaster*). Each of several California stomachs held more than 1,000 of these insects, and others but few less. In 10 stomachs taken in June the average percentage of ants was 76; in 10 taken in July, it was 87 percent. November was the month of least consumption, when the average of 34 stomachs was 7 percent. Of the 118 stomachs, 78, or 66 percent of the whole, contained ants, and 14 held nothing else, except a little rubbish in three, and in one a few seeds of filaree (*Erodium*). Inasmuch as certain ants in California, in the latter part of summer, make a business of harvesting seeds, probably this particular woodpecker had picked up a few ants that were thus employed. Hymenoptera other than ants are eaten by the flicker only occasionally, and average less than 1 percent of the yearly food.

Miscellaneous insects amount to nearly 5 percent. They consist of common crickets, wood crickets, mole crickets, caterpillars, white ants (*Termes*), spiders, and sow bugs (*Oniscus*). All of these suggest decaying logs and stumps, where the flicker obtains a large share of its food.

The following insects and crustaceans were identified in the food of the flicker:

COLEOPTERA.

Amara insignis.
Anisodactylus dilatatus.
Anisodactylus piceus.
Calathus ruficollis.
Platynus maculicollis.
Harpalus sp.

HYMENOPTERA.

Formica neorufibarbis.
Cremastogaster lineata.
Lasius sp.
Messor andrei.
Solenopsis geminata.
Prenolepis imparis.

CRUSTACEA.

Porcellio scabra.
Oniscus sp.

Vegetable food.—The vegetable food of the flicker includes many items. They may, however, be grouped under four heads: Mast, grain, fruit, and other vegetable food. Mast forms 10 percent of the food. It is taken fairly regularly, but in the greatest quantity in winter. It was contained in 15 stomachs, 1 holding nothing else. In one case it was English walnut, but in all others it appeared to be the meat of acorns. December showed the maximum amount, 40 percent. Grain was found only in stomachs taken in August, October, and November, the highest percentage being in August, about 17 percent. The total for the year was only 4 percent. It was all contained in 16 stomachs, and consisted of corn in 14 cases, barley in 1, and oats in 1. A stomach taken in November was entirely filled with corn. It is not likely, however, that the flicker ever does serious damage to corn or any other grain. The examinations do not indicate any great fondness for this food, and observation has never shown that the bird makes a practice of visiting grain fields.

Fruit was found in 39 stomachs, in 26 of which it was thought to be of cultivated varieties, but in the other 13 it was wild. Apples, cherries, grapes, prunes, and probably pears were the domestic fruits identified. One stomach was entirely filled with apple pulp and another practically so. Grapes are apparently the favorites. The wild varieties of fruit identified were pepper berries, elderberries, and gooseberries. Fruit pulp that could not be further determined was found in several stomachs and was classified as domestic, although it may have been wild. The aggregate of fruit for the year is 15 percent. While no complaints have been lodged against the flicker for depredations upon fruit, evidently it can do serious damage where it is abundant. It enjoys living in orchards or their immediate vicinity, and, as the stomachs show, does not hesitate to sample their products, but it eats most of its fruit in the latter part of the season, after cherries, apricots, peaches, and prunes have been gathered. September is the month of greatest consumption, 48 percent. Fruit is taken quite regularly during the rest of the year; but only 6 percent was eaten in June, the month of cherries, and 7 percent in July, the month when apricots are at their best, and none in August, the month of peaches and prunes. The damage done to fruit by the flicker probably consists in spoiling a few choice specimens, rather than in extensive destruction of the crop.

Various other substances make up the remaining vegetable food of the flicker, 17 per cent. Of these the most conspicuous is the seed of poison oak (*Rhus diversiloba*). These noxious seeds were found in 41 stomachs, and 1 was entirely filled with them. Very few are eaten in June and July, but they form an important article of diet through the fall and winter. The month of greatest consumption is October, when they constitute 40 per cent of the total food. The consumption of these seeds would be a decided benefit to man if they were ground up and destroyed in the stomachs. Unfortunately they are either regurgitated or pass through the intestinal tract uninjured and ready to germinate. The action of the stomach simply removes the outer covering, a white, wax-like substance, which is probably very nutritious, and is evidently relished by many birds. Birds are probably the most active agents in the dissemination of these noxious shrubs. On the other hand, these seeds, which are wonderfully abundant, afford food for thousands of birds during the winter, when other food is hard to obtain, and thus enable the birds to tide over the cold season to do their good work of destroying insects the next summer. Seeds of a nonpoisonous Rhus, some weed seeds, and a little rubbish were found in a few stomachs.

The flicker of California, and probably of the west coast in general, has one habit not observed in the eastern species. The mild climate and abundant food supply render migration unnecessary, but, like many other birds that nest in holes in trees, it likes shelter during the winter nights. As trees in which cavities can be made are not numerous enough, it pecks holes in buildings, as barns, schoolhouses, and churches. It often happens that the hole leads into the interior of the building and so proves useless to the bird, and it makes another and another till it hits the right place—in the cornice, for instance. Usually several holes are made before suitable shelter is found, and the consequent disfigurement and damage are sometimes serious.

SUMMARY.

In summing up the food of this flicker, two points are important—the destruction of ants and the eating and consequent scattering of the seeds of poison oak. The destruction of ants is a benefit, but it does not appeal to the horticulturist and farmer as does the destruction of well-known pests. While people are often annoyed by ants, they seldom suffer much damage by them. However, though ants do not destroy fruit or other crops to any great extent, they aid and abet other insects which do considerable harm. This is particularly true in regard to plant lice, which are housed, protected, and generally cared for by ants. Ants also continue the destructive work in timber begun by beetle larvæ until the wood is rendered worthless. The other insects eaten by the flicker are all more or less harmful, except a few useful ground beetles (Carabidæ). Most of the vegetable food is neutral; the amount of fruit and grain destroyed is not sufficient to constitute serious injury, but the scattering broadcast of the seeds of poison oak is harmful. As on the whole the flicker does more good than harm, it should be protected and encouraged.

OTHER WOODPECKERS.

Several other species of woodpeckers inhabit the State of California but, excepting the Lewis woodpecker, they are neither so numerous nor so generally distributed as those already treated. Their food consists in the main of the same elements, although the proportions vary with the species. The Lewis woodpecker (*Asyndesmus lewisi*) is perhaps the most important of these species, but since only 23 of its stomachs are available for examination, a definite statement of its food during the year can not yet be made. It appears to eat rather more vegetable than animal food, and in fall and winter eats large quantities of acorns. In the selection of its animal food it resembles the flicker in showing a decided taste for ants and other Hymenoptera.

Dr. C. Hart Merriam contributes the following note on this species:

> The Lewis woodpecker is one of the commonest and most widely distributed woodpeckers of California, in these respects coming next after the California woodpecker (*Melanerpes formicivorus bairdi*). But owing to its habit of breeding at higher altitudes it is less often seen in the lower and more highly cultivated parts of the State, except during migration. It breeds mainly in the Ponderosa pine forests of the mountains (Transition zone), whence, usually in early September, it descends into the blue oak and Digger pine belt of the foothills to spend the winter.
>
> Like the California woodpecker, it is a skillful flycatcher, pursuing and capturing insects in mid-air. But in fall and winter its principal food is acorns, of which it eats surprising quantities. At this season is is usually seen in small flocks of from 6 to 20 birds, each carrying a large acorn in its bill.
>
> These woodpeckers are very fond of ripening apples, and in early September descend in flocks upon the orchards, particularly those of the higher foothills, and in certain cases, if let alone, destroy practically all the fruit. I have heard of their depredations in various parts of the State and have personally seen the birds, in early September, circling about the orchards and diving down into the apple trees between Round Mountain and Montgomery Creek, and in Fall River Valley, Shasta County, and in Scott Valley and the upper canyon of Klamath River near Beswick, in Siskiyou County. At the latter place they are so destructive that during the ripening of the fruit gunners employed to shoot them frequently kill 25 in a day, and in early September, 1907, I was told that as many as 50 had been killed in one day.

While, as stated above, our investigations have not proceeded far enough to enable a final statement to be made regarding this woodpecker's economic status, enough is known to justify the belief that the bird, by its destruction of insects the year round, is much more beneficial than injurious, despite its occasional depredations on apples and other fruit.

The sapsuckers of the genus *Sphyrapicus* have been accused of doing much harm by boring into fruit and other trees for sap, and while the charge is well founded the injury is largely counterbalanced by the bird's destruction of insects. The sapsuckers are not numerous enough, however, to be reckoned an important factor either way.

FLYCATCHER FAMILY.

(Tyrannidæ.)

Among our useful birds the flycatchers (Tyrannidæ) take high rank. As is well known their principal food consists of insects captured in mid-air. If the name flycatcher implied that these birds subsisted largely upon flies (Diptera), it would be a misnomer, for nearly all the species eat far more Hymenoptera than Diptera. In fact waspcatcher would be much more appropriate. The name, however, is intended to suggest the idea that the birds are flying when they catch their prey. The capture of food in this way implies that the species are strong, rapid flyers, and capable of making quick turns in the air. In addition to flying insects, the flycatchers eat spiders and other wingless forms and some vegetable food which they pick up from the ground or snatch from trees. The animal food of the 6 species discussed in the following pages averages 90 percent of their diet.

Several flycatchers in the eastern part of the country are quite domestic in their habits and frequent orchards and gardens, and some species nest about buildings. In California some of the corresponding species have not yet become so accustomed to the presence of man and his works, but they are learning rapidly. The black phoebe is perhaps as familiar there as is the common phoebe in the East; but the kingbird of California has not fully decided that the orchard is a safe and altogether desirable place for nesting purposes. Sixteen species and subspecies of flycatchers have been found within the limits of this State. Six of them are numerous enough to be of economic importance.

ASH-THROATED FLYCATCHER.

(*Myiarchus cinerascens.*)

The ash-throated flycatcher is a summer resident of the lower and warmer parts of the State. Its habit of nesting in cavities perhaps causes it to seek the vicinity of farm buildings, where such accommodations are numerous. It builds in hollow trees also, which may often be found in the older orchards. The eastern species (*M. crinitus*), which nests in hollow trees, habitually places the shed skin of a snake in the walls of its nest. The reason for this is not plain, but the writer has never seen or heard of a nest in which the snake skin was lacking. The ash-throat occasionally does the same thing, but apparently does not consider the snake skin indispensable. Though an orchard bird, it seldom eats any cultivated fruit, but confines its diet largely to insects, most of which are either injurious or neutral.

In the following investigation of the ash-throat, 80 stomachs were used, collected from April to December inclusive, but only one in each month after July. Animal food amounts to 92 percent and vegetable to 8 percent for the season. Stomachs taken in April, May, August, October, and November contained no vegetable food whatever. The one stomach taken in September held 44 percent of elderberries, which is exceptional. A greater number of stomachs in this month would probably have reduced this percentage considerably.

Animal food.—Of the animal food, beetles, almost entirely of harmful species, amount to 5 percent. The two families most prominent in the food are the longicorns (Cerambycidæ) and the metallic woodborers (Buprestidæ), which are the very ones whose larvæ are so extensively eaten by woodpeckers. Next to these were the click beetles (Elateridæ), that bore into various plants and do much damage, and a few weevils or snout beetles (Rhynchophora). A ground beetle (Carabidæ) was found in one stomach, and a ladybird (Coccinellidæ) in another, these being the only useful beetles taken.

Bees, wasps, and a few ants (Hymenoptera) amount to 27 percent. They are eaten regularly in every month when the bird is on its summer range. Five stomachs were taken in the vicinity of an apiary, but not one of them contained a trace of a honey bee, though one bird had eaten 24 percent of robber flies (Asilidæ), which have been known to prey upon bees.

Bugs (Hemiptera) aggregate about 20 percent of the food of the ash-throat, which is the largest showing for that order of insects yet found in the food of any flycatcher. They were all eaten in the months from May to August inclusive, and form a good percentage in each of those months. They belong to the families of stinkbugs (Pentatomidæ), shield bugs (Scutelleridæ), leafhoppers (Jassidæ), jumping plant lice (Psyllidæ), common plant lice (Aphididæ), tree hoppers (Membracidæ), cicadas (Cicadidæ), and assassin bugs (Reduviidæ). The last is a family of predaceous insects which are useful, as they destroy some harmful insects, but all the others are injurious, and some are pests. While many of these are taken upon the wing, probably some are picked from plants. One bird was seen on a mustard plant feeding upon the plant lice, which completely infested the plant. One stomach was entirely filled with tree hoppers and two with cicadas.

Flies (Diptera) amount to about 14 percent and were eaten in nearly every month. Robber flies were identified in two stomachs, one of which has already been referred to. Most of the others were of the family of the common house fly (Muscidæ).

Caterpillars were found in 20 stomachs and moths in 7. Together they amount to 19 percent of the food. This shows that caterpillars are a favorite article of food with this bird, and proves that it does not take all its food on the wing. While no stomach was entirely filled with caterpillars, one contained nothing but moths.

Grasshoppers formed about 5 percent of the food, and were mostly taken in May, June, and July. One stomach contained nothing else. As they do not often come within reach of flycatchers, these insects must be especially sought for.

Various other insects and spiders amount to a little more than 3 percent. Among these the two most prominent were dragonflies and Raphidia. These last are small insects with remarkably long necks, and as they prey upon other insects and are said to feed upon the larvæ of the codling moth, their destruction by birds is to be deplored. Spiders are eaten by the ash-throat quite regularly, but not extensively. Apparently, most birds take spiders when found, but do not seek for them.

Vegetable food.—Vegetable food was found in 9 stomachs. Of these, 5 contained remains of elderberries; 2, bits of other small fruit; and 2, skins which might have been those of cultivated varieties. The total for the year is 8 percent.

Feeding of young.—Besides the examination of stomachs of the ash-throated flycatcher, observations were made upon the feeding of a nest of young situated in the cornice of an abandoned ranch house. The nest contained four young about a week old when first discovered. The number of feedings and times of observations are given in the following table:

Date.	Hours in forenoon.	Number of feedings.	Hours in afternoon.	Number of feedings.
June 18			12.59–1.59	9
June 22	10.48–11.48	14	2.07–3.07	9
June 26			2.13–3.13	18
Do			5.56–6.26 (half-hour.)	6
June 27	5.15– 6.15	28		
Do	11.27–12.27	9	4.47–5.47	9
June 28	5.26– 6.26	16		

In all, the nest was observed for eight and one-half hours and 119 feedings were noted, or an average of 14 feedings per hour. Both parent birds took part in the feeding until the female was unfortunately killed after the first hour of feeding on the morning of June 27. It will be noted that during this early hour more feedings were observed than at any other, and that at practically the same hour the next morning, June 28, the male bird alone was able to feed only 16 times. However, the young did well, and left the nest that afternoon. As the day was about fourteen hours long when the above notes were taken, each of the young birds must have been fed about 49 times every day, or 196 insects in all. It is safe to say that the parents would eat enough more to bring the total up to 250. Several nests of this bird in an orchard would make quite a difference in the number of insects surviving to propagate the next year's supply.

SUMMARY.

From the foregoing it is evident that the ash-throat attacks no product of husbandry, but keeps up an incessant war upon insects. Of these it devours a vast number in the course of the year, mostly harmful species. This bird likes to reside in the vicinity of houses, gardens, and orchards. Let it be encouraged by all means.

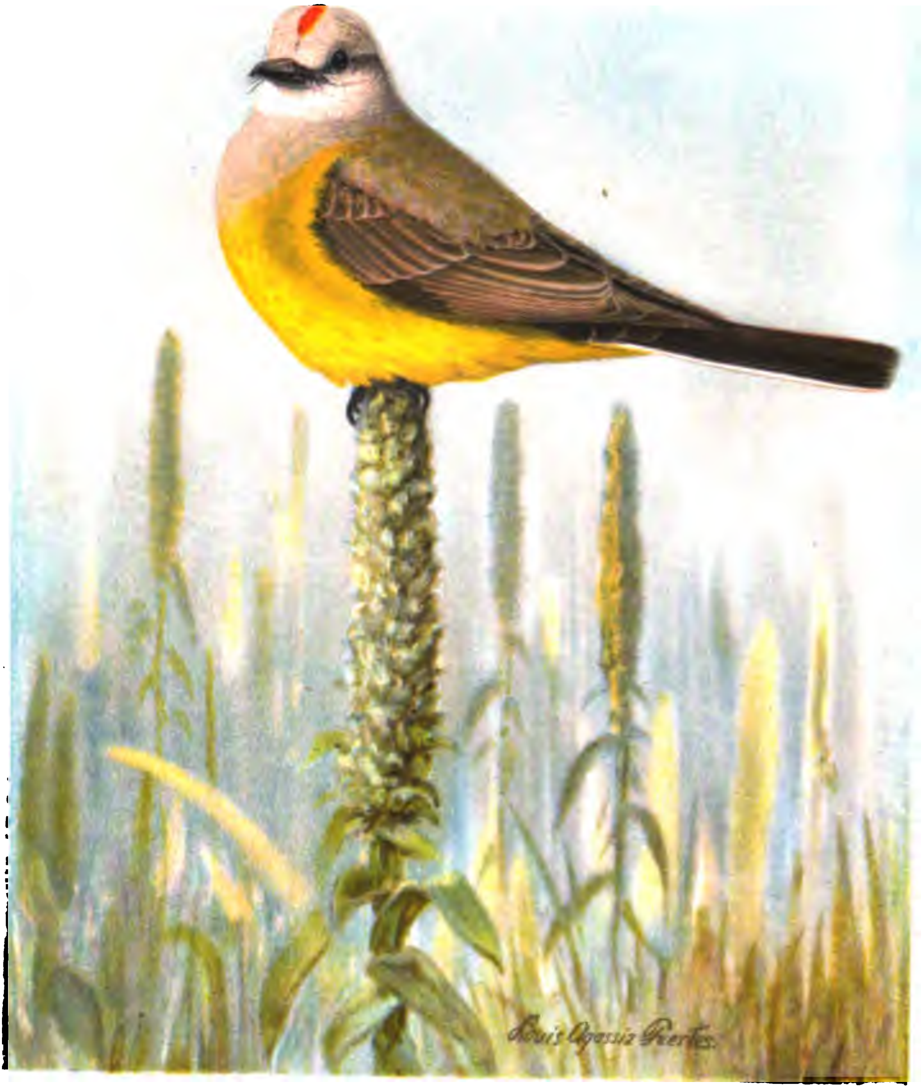
ARKANSAS KINGBIRD.

(*Tyrannus verticalis.*)

The Arkansas kingbird (Pl. II) inhabits the lower and warmer part of the State, mainly as a summer resident. It is not so domestic as its eastern relative, the common kingbird, and seems to prefer the hill country, with scattering oaks, rather than the orchard or the vicinity of towns or ranch buildings.

For the investigation of the kingbird's food 78 stomachs were available. Most of them were taken from March to July inclusive, but a few in September, October, and December. The bird's yearly food is made up of 87 percent of animal matter to 13 percent of vegetable.

Animal food.—The animal food is composed of insects and a few bones of a batrachian (tree frog or salamander). Both the eastern and western kingbirds have been accused of destroying honey bees (*Apis mellifera*) to a harmful extent. It is said that the birds linger about the hives and snap up the bees as they return home laden with honey. Remains of honey bees were searched for with special care, and were found to constitute 5 percent of the food. Thirty-one individuals were discovered in 5 stomachs. Of these, 29 were drones, or males, and 2 were workers. In 3 stomachs containing males there was no other food, and when it is borne in mind that there are thou-



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ARKANSAS KINGBIRD

sands of worker bees to one drone, it appears that the latter must be carefully selected. As a rule, the destruction of drones is not an injury to the colony, and often is a positive benefit. The food of the eastern kingbird shows practically the same ratio between drones and workers. Hymenoptera other than honey bees amount to 38 percent, and include wild bees, wasps, and ants, with a few parasitic species. The latter are very useful insects, and their destruction is an injury, but fortunately the kingbird is not especially fond of them.

The late Walter Bryant, of Santa Rosa, Calif., says:

> Mr. A. Barnett, of San Diego County, had 300 swarms of bees, which attracted the flycatchers to such an extent that he made some investigations to ascertain to what extent they might be damaging the bee industry.
>
> Over 100 flycatchers were dissected, principally Arkansas flycatchers and phoebes (Black and Say's?). In all of the Arkansas flycatchers drones were found, but no working bees, although in many cases the birds were gorged. In most of the phoebes drone bees were found; the only exception was that of a phoebe (Say's?) in which a bee's sting was found in the base of the tongue.
>
> The birds were all shot about apiaries and were seen darting upon and catching the bees.[a]

Such testimony is sufficient to clear these flycatchers of the suspicion that they interfere with the bee industry.

Beetles of various families form about 14 percent of the food. They are all harmful species except a few predaceous ground beetles and ladybird beetles. They were taken very regularly through the months, and appear to be a favorite food.

Orthoptera—grasshoppers and crickets—amount to 20 percent. They were taken pretty regularly through all the months. Even the 3 stomachs secured in December show an average of 44 percent. Probably few of these were caught on the wing, and their abundance in the food indicates that this bird, like many others, forsakes its usual style of feeding and goes to the ground to catch grasshoppers whenever they are numerous. Two stomachs were entirely filled with these insects, and in several others they amounted to over 90 percent of the contents.

Miscellaneous insects, consisting of caterpillars and moths, a few bugs, flies, and a dragonfly, constituted 10 percent. Several stomachs contained a number of moths, and one was entirely filled with them. Not many birds eat these insects extensively in the adult form, while the larvæ (caterpillars) are a prominent feature of the diet of most insectivorous birds. Besides insects, bones of some batrachian, probably a tree frog, were found in three stomachs and an eggshell in one. They amount to only a trifling percentage. Frogs or salamanders seem queer food for a flycatcher, but their bones have been found in the stomachs of several species of tree-haunting insectivorous birds.

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[a] Zoe, IV, pp. 57–58, 1893.

The following is a list of insects identified in the stomach of the Arkansas kingbird:

COLEOPTERA.

Platynus sp.
Aphodius fimetarius.
Amphicoma ursina.
Cremastochilus sp.
Geotrupes sp.
Megapenthes turbulentus.
Epicauta sp.
Hydaticus stagnalis.
Agabus sp.
Silpha ramosa.
Staphylinus luteipes.
Balaninus sp.

HYMENOPTERA.

Apis mellifera.
Prosopis affinis
Habropoda sp.
Melissodes sp.
Andrena sp.
Cryptus sp.
Ophion bilineata.

HEMIPTERA.

Euschistus servus.
Nezara sp.
Podisus modestus.
Calocoris rapidus.
Eurygaster alternatus.

Vegetable food.—The vegetable food of the Arkansas kingbird amounts to about 13 percent, and consists mostly of fruit. It was all contained in 15 stomachs, of which 10 held elderberries (*Sambucus*) and 5 various small berries not positively identified. One also contained an olive, the only cultivated fruit found. A few seeds also were noted.

SUMMARY.

In a summary of the economic significance of the food of this kingbird it should be noted that the bird must be judged by its destruction of insects, for, since it does not eat any product of cultivation to an appreciable extent, its vegetable food can be disregarded. The offense of eating honey bees, so long laid at this bird's door, is practically disproved, for the more or less useless drones eaten far outnumber the useful workers. The injury the kingbird does, if any, is by eating predaceous beetles and parasitic Hymenoptera, but it takes these in such small numbers as to leave no reasonable doubt that the bird is one of our most useful species.

CASSIN KINGBIRD.

One other species of *Tyrannus* (*T. vociferans*), commonly known as the Cassin kingbird, occurs in the southern half of the State, where it frequents orchards and ranches. It is less abundant than the Arkansas kingbird, but has similar habits, and an examination of several stomachs shows that the food of the two species is practically the same.

SAY PHOEBE.

(*Sayornis saya.*)

While the Say phoebe inhabits California throughout the year, it is locally wanting in summer in many places west of the Sierra. In the fruit-growing regions visited, the writer met with only one individual during the spring and summer months, but these phoebes became fairly numerous in September, and increased in numbers as the season advanced. The investigation of their food was based upon the examination of 86 stomachs, taken in every month from September to March inclusive, and 2 taken in June. This bird was shown to be one of the most exclusively insectivorous of the family, although no stomachs were available for the months when insects were most numerous. The food consists of 98 percent of animal matter and 2 percent of vegetable.

Animal food.—As a number of predaceous ground beetles (Carabidæ) were in these stomachs, a separate account was kept of them. They amount to somewhat over 5 percent, and are pretty evenly distributed through the months, except February, in which 25 percent were eaten. These were in one stomach, which they half filled, and as only 2 stomachs were taken in that month, the percentage was probably made too great. It seems impossible that all these beetles, which are rather averse to flying, could have been caught on the wing, especially since none were taken in the warmer months, when they are most active. In the other beetle food, which amounts to 10 percent, a few ladybirds (Coccinellidæ) were found. These and the ground beetles must be recorded against the bird, but the fault is not serious. The remainder of the beetles were all of injurious or neutral species.

Hymenoptera, including quite a number of ants, amount to 35 percent, and were contained in 69 stomachs, or over 78 percent of the whole. This illustrates the statement that these birds are wasp-catchers rather than flycatchers. A few parasitic species were among the rest. Bugs, as is so often the case, were eaten quite regularly, but in rather small quantities. They amount to about 5 percent of the food, and belong to the following families: Stinkbugs (Pentatomidæ), the squash-bug family (Coreidæ), leaf bugs (Capsidæ), negro bugs (Corimelænidæ), leafhoppers (Jassidæ), tree hoppers (Membracidæ), and assassin bugs (Reduviidæ). These last are reckoned as useful insects, but they were identified in only one stomach.

Flies (Diptera) aggregate 10 percent of the food, and were eaten mostly in the months of January, March, and November; but probably this is accidental and would not hold true with a greater number of stomachs. The only family identified was that of the common house fly (Muscidæ). One stomach was entirely filled with them. Moths and caterpillars (Lepidoptera) appeared in 27 stomachs, and amount to something more than 10 percent of the food. Moths were found in 15 stomachs and caterpillars in 12. This is contrary to the usual rule that in this order of insects the larvæ are eaten by birds much more freely than are the adults.

Grasshoppers and crickets (Orthoptera) are eaten by the Say phoebe to the extent of 14 percent, which is the highest record of any flycatcher except the Arkansas kingbird. These, taken in connection with the ground beetles, ants, and caterpillars, indicate a somewhat terrestrial habit of feeding. Nearly 40 percent of the grasshoppers consumed were taken in September, after which they steadily decreased in quantity. One stomach was entirely filled with them.

Miscellaneous insects, spiders, and a few other creatures make up the rest of the animal food, about 8 percent. Of these, spiders were found in 10 stomachs, dragonflies in 5, sowbugs (*Oniscus*) in 1, and another unidentified crustacean in 1.

Vegetable food.—The vegetable food of the Say phoebe amounts to 2 percent, and is made up of a little fruit, a few seeds, and some rubbish. One seed and a stem of a fig were the only indications of cultivated fruit. Remains of elderberries were noted in 3 stomachs, seeds in 4, pulp of a large seed or nut in 1, and rubbish in 4.

SUMMARY.

The economic relations of the Say phoebe depend wholly upon its animal food, for it eats practically no vegetable matter of any interest to man. That it takes a few useful insects can not be denied, but the stomachs' contents show that they are far outnumbered by harmful species, and the balance is clearly in favor of the bird.

BLACK PHOEBE.

(*Sayornis nigricans.*)

The black phoebe inhabits the lower valleys of California, and in most parts can be found throughout the year. For a nest site it selects the wall of a canyon, a shed, the overhanging eaves of a barn, or, better still, a bridge. It has a pronounced preference for the vicinity of water. Even a watering trough by the roadside usually has its attendant phoebe.

While camping beside a stream in California, the writer observed the feeding habits of the black phoebe. The nesting season was over, and apparently the birds had nothing to do but capture food. This they appeared to be doing all the time. In the morning, at the first glimmer of daylight, a phoebe could always be seen flitting from rock to rock, and probably it caught an insect on each flight. This activity was kept up all day. Even after supper, when it was so dark that notes had to be written by the aid of the camp fire, the phoebes were still hunting insects.

Observations like these convince any reasoning person that the number of insects destroyed in a year by this species is something enormous, and the examination of stomachs confirms field observations. This bird eats a higher percentage of insects than any flycatcher yet studied except the western wood pewee. For the study of this phoebe's food 333 stomachs were available, collected in every month in the year and from various parts of the State. They show 99.39 percent of animal matter to 0.61 percent of vegetable.

Animal food.—In examining the food contained in the stomachs of the black phoebes, account was kept of the beetles that are generally supposed to be useful, namely, the ground beetles (Carabidæ), the ladybirds (Coccinellidæ), and the tiger beetles (Cicindelidæ). It was found that these beetles were eaten pretty regularly throughout the year; in fact, there is no month which does not show a certain percentage of them. The average for the year, however, is only 2.82, or practically 3 percent, not a heavy tax on the useful beetles. Other beetles, all more or less harmful, amount to 10 percent. They were eaten in every month, and though the quantity varies to some extent, the variation appears to be accidental.

Hymenoptera amount to over 35 percent of the yearly food. They were found in 252 out of the 333 stomachs, and in 11 there was no other food. They are eaten throughout the year. March is the month of least consumption, with only 1 percent, while August shows the maximum, nearly 60 percent. A few ants and several parasitic species are eaten, but the great bulk of this item is made up of wild bees and wasps. Not a trace of a honey bee was found in any stomach.

Hemiptera of several families were eaten to the extent of about 7 percent. They were pretty uniformly distributed through the food of the year, except that none were taken in May, which, however, is probably accidental. Four of these families are aquatic, which partly explains why the bird is so fond of the vicinity of water. The Reduviidæ are insectivorous, and therefore useful. They were found in but one stomach. The other families are vegetable feeders; all of them likely to be harmful, and most of them pests. The plant lice found in the food are rather unexpected, but, as already noted, flycatchers do not take all their food on the wing.

Flies (Diptera) were eaten by the black phoebe to the extent of over 28 percent. They appear in every month, and range from 3 percent in August to 64 percent in April. They were found in 127 stomachs, 10 of which contained nothing else. The house-fly family (Muscidæ), the crane flies (Tipulidæ), robber flies (Asilidæ), and one horsefly (Tabanidæ) were the only ones identified. Grasshoppers and crickets are not extensively eaten by the phoebe. They amount to about 2½ percent for the year, being eaten rather irregularly; five months show none at all. The greatest consumption was in April, nearly 8 percent.

Moths and caterpillars are eaten to the extent of 8 percent. They were found in 72 stomachs—moths in 38, caterpillars in 32, and both in 2. A few unidentified insects and several miscellaneous ones, principally dragonflies, with some spiders, make up the rest of the animal food, 6 percent. Dragonflies are taken quite frequently, but generally in no great numbers. One stomach was entirely filled with them, and several were nearly so. The fact is, these insects are so large that often a single one fills a phoebe's stomach. These insects are too strong and agile upon the wing to be captured by anything less expert than a flycatcher, and in the few instances where they appear in other birds' stomachs they were probably found dead. The spiders eaten by the phoebe are perhaps snapped from the tops of weeds as the bird flies over, or taken from the web. While quite frequently eaten, they form only a small percentage of the diet.

The following is a list of insects identified in the stomachs of the black phoebe:

COLEOPTERA.

Elaphrus riparius.
Triæna longula.
Bradycellus rupestris.
Laccobius ellipticus.
Philonthus pubes.
Hippodamia convergens.
Coccinella transversoguttata.
Coccinella californica.
Chilocorus orbus.
Cryptorhopalum apicale.
Hister bimaculatus.
Saprinus obscurus.
Saprinus lugens.
Saprinus lubricus.
Carpophilus hemipterus.
Heterocerus tristis.
Canthon sp.
Aphodius granarius.
Aphodius vittatus.
Aphodius ungulatus.
Amphicoma ursina.
Gastroidea sp.
Lina scripta.
Diabrotica soror.
Blapstinus pulverulentus.
Corphyra sp.
Notoxus alamedæ.

HEMIPTERA.

Hygrotrechus sp.
Largus succinctus.

In addition to the above species the following families of Hemiptera were identified:

Giant water bugs (Belostomatidæ).
Creeping water bugs (Naucoridæ).
Broad-shouldered water striders (Veliidæ).
Water striders (Hydrobatidæ).
Assassin bugs (Reduviidæ).
Leaf bugs (Capsidæ).
Red bugs (Pyrrhocoridæ).
Chinch-bug family (Lygæidæ).
Stink bugs (Pentatomidæ).
Leafhoppers (Jassidæ).
Tree hoppers (Membracidæ).
Jumping plant lice (Psyllidæ).
Plant lice (Aphididæ).

Vegetable food.—The vegetable food of the black phoebe amounts altogether to only 0.61 percent, and may be classified under two heads: Fruit and other vegetable matter. Fruit forms 0.34 percent, and the only species identified were elderberries in 19 stomachs, dogwood (*Cornus*) in one, and *Rubus* (blackberries or raspberries) in one. This last may have been cultivated; and some fruit skins found in 1 stomach may also have been of a domestic variety. Miscellaneous vegetable food consists of poison oak seeds in 2 stomachs, a catkin in 1, and rubbish in 1.

Food of young.—Among the 333 stomachs of the black phoebe were those of 24 nestlings, varying in age from 1 to 2 weeks. Their food was tabulated by itself to ascertain if it differed from that of the adults. No great difference was apparent in the kind of food eaten nor in the relative proportions. One point, however, was noted. The percentage of animal food was a little lower than in the adults; not because the young had intentionally eaten any vegetable food, but because, along with other food, the parents had fed a quantity of rubbish, dead grass, leaves, and the like. The same apparent carelessness as to the food of their young has been observed in other species.

SUMMARY.

In a summary of the food of the black phoebe the vegetable part may be dismissed as unimportant. Of the insect food we have less than 3 percent of theoretically useful beetles, a few parasitic Hymenoptera, and a few dragonflies, say, 5 percent in all, to offset 94 percent of harmful species. This phoebe is an efficient insect destroyer, and is an invaluable asset to the people of California or any other State it may inhabit. It should be rigidly protected and in every way encouraged.

WESTERN WOOD PEWEE.

(*Myiochanes richardsoni.*)

The western wood pewee is a familiar sight in the fruit-growing sections of the State, where its time is spent in a tireless search for insects. Wherever in the orchard there is a dead limb, there on the outermost twig perches the pewee, and from its lookout sallies forth to snatch up any luckless insect that comes within range. Several such perches are usually to be found not far apart, and the bird occupies them in turn as the game becomes scarce in one or the other place. The little western flycatcher (*Empidonax difficilis*) has the same habits, and shares these watchtowers with the pewee. Observation of one of these perches for three minutes, watch in hand, furnished a good idea of the bird's industry. In the first minute it took 7 insects, in the second 5, and in the third 6, or 18 in the three minutes.

Apparently it had been doing the same thing for an hour, perhaps all the morning. These observations were made at 10 a. m., when the air was warm and insects were on the wing. Either the same bird or another was watched the next day at 9 a. m. near the same spot, and 17 captures were noted in eight minutes. This morning was cooler, and fewer insects were abroad than on the previous day. The mean of these two observations is 4 insects per minute. If the bird keeps this up for even ten hours a day, the total is 2,400 insects. It hardly seems possible that one bird could eat so many unless they were very small, but this pewee is rarely seen when it is not actively hunting. When the young are in the nest, the parents must make great havoc with insects if the nestlings are fed at the above rate.

The pewee remains in California only about six months in the year, but fortunately this is the season when insects are most numerous. One hundred and thirty-seven stomachs, taken in the months from April to September inclusive, were available for examination. Animal matter formed 99.91 percent of the contents and vegetable matter 0.09 percent, or less than one-tenth of 1 percent. The percentage of animal matter is the highest yet found in the food of any flycatcher.

Animal food.—Beetles amount to about 5 percent of the food. With the exception of Carabidæ, found in 4 stomachs, and Coccinellidæ, in 5, all were either harmful or neutral species.

The following beetles were identified:

Coccinella 9-notata nevadica.
Coccinella californica.
Coccinella transversoguttata.
Hippodamia ambigua.
Hippodamia convergens.
Hister bimaculatus.
Saprinus plenus.
Carpophilus hemipterus.
Aphodius vittatus.
Agrilus sp. nov.
Agriotes sp.
Gastroidea sp.
Blapstinus sp.
Ptilinus basalis.
Baris rubripes.

Hymenoptera aggregate over 39 percent, and are of wild species—that is, there are no domestic bees among them. They were found in 93 stomachs, and in 14 there was nothing else. Parasitic species were identified in 7 stomachs and ants in only 2—an unusually small record for ants, which are favorite food with flycatchers.

Hemiptera, or bugs, are evidently not esteemed as an article of diet by this bird, for they amount to less than 2 percent of the food. None were eaten in April or May, but nearly half the whole number were taken in August.

Diptera amount to nearly 40 percent, slightly exceeding Hymenoptera. No other flycatcher has yet been noted whose food contained more Diptera than Hymenoptera; hence the name flycatcher is peculiarly applicable to this pewee. Diptera were found in 84 stomachs, and 20 contained no other food. This would seem to indicate that flies are preferred to other insects. The families Muscidæ, Tipulidæ, and Asilidæ were recognized.

Caterpillars and moths amount to nearly 5 percent. Though not taken in great numbers, they are eaten regularly through the season. September shows the greatest consumption—over 14 percent. Moths were found in 18 stomachs and caterpillars in 4. One stomach was entirely filled with the remains of moths.

Sundry insects, amounting to nearly 9 percent, make up the rest of the animal food. Dragonflies were found in 7 stomachs, and 1 contained nothing else. Ephemerids were in 4 stomachs, lace-winged flies in 1, spiders in 3, and the so-called jointed spiders in 1.

The character of the food shows that it is taken on the wing more exclusively than that of any other bird yet examined. Of the creatures that do not fly, ants were found in 2 stomachs, caterpillars in 4, spiders in 3, and jointed spiders in 1. As some ants fly, these may have been taken in mid-air, but they were too badly broken to determine this point.

Vegetable food.—Vegetable matter was found in 4 stomachs, but in 3 of these it was mere rubbish. One contained seeds of the elderberry, the only vegetable food observed.

SUMMARY.

The western wood pewee, while often an inhabitant of the orchard, does not deign to taste of its product, if the above record may be assumed to be conclusive. Its diet is composed almost exclusively of insects, and of these a large majority are harmful species.

WESTERN FLYCATCHER.

(*Empidonax difficilis.*)

The western flycatcher avoids alike the hot valleys and the high mountains of California during the warmer months, but is more generally distributed in migration. For a nesting site it selects a tree, a crevice among the roots of an overturned stump, a bracket under a porch, a beam under a bridge, or a hole under an overhanging sod on the bank of a stream. It has much the same liking for water as the black phoebe, though even more pronounced. A small stream running through or near an orchard appears to supply ideal conditions for this little flycatcher, as the orchard makes an excellent foraging ground, and if it does not afford a nesting site, the bank of the stream will. The bird is quiet and unobtrusive, and often the first notice one has of its presence is to see it dart from the end of a near-by twig into the air in pursuit of an insect. It seems to be thus engaged all day; in fact, the writer has never seen one of these birds when it was not in search of food.

In the laboratory investigation of the food of the western flycatcher 141 stomachs were examined. They were collected from March to October inclusive, and probably give a fair idea of the bird's food for these months. Analysis gives 99.28 percent of animal food to 0.72 percent of vegetable; in other words, there was less than three-fourths of 1 percent of vegetable matter. Only one other flycatcher, the western wood pewee, eats so little vegetable food.

Animal food.—In this analysis a separate account was kept of the ladybird beetles (Coccinellidæ). This bird appears to eat more of them than does any other flycatcher, but the number for the whole season is not large enough to be very serious. The greatest consumption occurred in August, a little more than 7 percent. The average for the season is 2⅓ percent. Other beetles amount to nearly 6 percent, nearly all harmful, the exception being a few ground beetles (Carabidæ).

Hymenoptera form the largest constituent of the food of this as of most other flycatchers. They amount to over 38 percent, and are an important item during every month of the bird's stay on its summer range. The highest percentage is in March, 61; but as only 3 stomachs were taken in that month, the record can not be considered as final. June shows 52 percent, and is probably nearer the true maximum, although August and September do not fall much below. Ants were found in 14 stomachs, and parasitic Hymenoptera in but 2. Hymenoptera in general were found in 99 stomachs, and 6 contained nothing else. No honeybees were identified.

Hemiptera (bugs) amount to nearly 9 percent of the food. They were found in 49 stomachs, 2 of which were entirely filled with them. The greatest number were taken in August, when they constituted 29 percent. The following families were identified:

Stink-bug family (Pentatomidæ).
Chinch-bug family (Lygæidæ).
Leaf-bug family (Capsidæ).
Leafhopper family (Jassidæ).
Tree-hopper family (Membracidæ).

Diptera amount to a little more than 31 percent of the whole food. They rank next to Hymenoptera, and, like those insects, are taken very regularly during every month of the bird's stay in the State. While October is the month of maximum consumption, 47 percent, several other months are but little below. Only 3 families were identified: The crane flies (Tipulidæ), the soldier flies (Stratiomyiidæ), and the house flies (Muscidæ).

Lepidoptera, in the shape of moths and caterpillars, amount to about 7 percent for the year, and were found in every month except March. They appeared in 36 stomachs, of which only 7 contained the adult insects—moths—and 29 the larvæ or caterpillars. This taste is in contrast with that of the black phoebe and the wood pewee, which prefer moths, but is quite in accordance with the general rule among insectivorous birds. Special interest attaches to this item of the bird's food from the fact that larvæ of the codling moth were found in 3 stomachs. In one 15 were counted, which amounted to 89 percent of the food. In another they were too badly broken to be counted, but formed 55 percent of the contents. In the third only 1 was found, amounting to 3 percent. Evidently these insects were hibernating in a crevice in the bark of a tree or some similar place, and were there discovered by the flycatcher.

A few unidentified insects and some spiders make up the remainder of the animal food—about 6 percent. Spiders were found in 19 cases—in 1 stomach amounting to 70 percent—and these, with the caterpillars, particularly the codling-moth larvæ, show that a considerable percentage of the food of this bird is not caught on the wing.

The following is a list of insects identified from the stomachs of the western flycatcher:

COLEOPTERA.

Aleochara bimaculata.
Hippodamia ambigua.
Hippodamia convergens.
Coccinella californica.
Scymnus sp.
Telephorus divisus.
Aphodius sp.
Limonius infuscatus.
Gastroidea cyanea.
Diabrotica soror.
Monoxia sordida.
Epitrix sp.
Eulabis rufipes.
Blapstinus ruficeps.
Deporaus glastinus.
Balaninus sp.

DIPTERA.

Stratiomyia maculosa.

LEPIDOPTERA.

Carpocapsa pomonella.

Vegetable food.—Vegetable matter was found in 16 stomachs, though some of it could not properly be called food. One stomach contained seeds of Rubus fruit (blackberries or raspberries); 7, seeds of elderberries; 1, the skin of an unidentified fruit and a seed of tarweed (*Madia*); while 6 held rubbish. The Rubus fruit might have been cultivated, but probably was not.

Food of young.—Among the stomachs whose contents have been discussed were those of 15 nestlings, varying in age from 48 hours to 2 weeks, which show no marked differences from those of adults. Only 2 of these stomachs contained any vegetable matter; in 1 was 15 percent of rubbish; in the other 3 percent. Gravelstones were found in several cases, and have been observed in the young of other insectivorous birds, even when not found in adults of the same species.

The young in one nest were fed 24 times in an hour. Owing to the nest's location the number of nestlings was not ascertained. If there were four, as is probable, and the feeding was continued fourteen hours, each was fed 84 times during the day.

SUMMARY.

From the foregoing it is evident that neither the farmer nor the fruit grower has anything to fear from the western flycatcher. Practically it eats no vegetable food, and its animal diet contains less than the normal proportion of useful elements. It should be rigidly protected at all seasons.

OTHER FLYCATCHERS.

Four or more other species of the genus *Empidonax* occur within the limits of California. They are not so domestic as the one just discussed, but their food habits are quite similar. One, *E. trailli*, is locally quite abundant, but chooses the willows along water courses for its home rather than the orchards. The others are less widely distributed and therefore of less economic importance. A few stomachs of each species have been examined, but they indicate no remarkable differences in food habits from those of the western flycatcher.

HORNED LARK.

(*Otocoris alpestris chrysolæma*, *rubida*, and other subspecies.)

Not only in California, but in a considerable portion of temperate North America, some form of the horned lark occurs wherever plain or valley presents the condition suited to its peculiar needs. The former generic name, *Eremophila*, or desert lover, was peculiarly appropriate, but unfortunately it was necessary to displace it. Bare, level ground with scant herbage and no trees or shrubs appears to be the ideal condition for the horned lark. While on the Pacific coast they are not called upon to endure excessive cold, yet elsewhere they endure low temperatures not only with indifference but with apparent pleasure. The writer has met them on an open prairie when the temperature was nearly 30 degrees below zero, and though a fierce gale was blowing from the northwest they did not exhibit the least sign of discomfort, but rose and flew against the wind, then circled around and alighted on the highest and most windswept place they could find. Probably they remain through the night in these bleak spots, for they may frequently be seen there after sunset. Most animals seek shelter from wind and cold, even though it be nothing but the leeward side of a ridge or hummock, but the horned lark refuses to do even this, and by preference alights on the top of the knoll where the wind cuts the worst. It seems strange that in so small a body the vital heat can be maintained under such adverse conditions, but if one of these birds be examined, its body will be found completely covered with a thick layer of fat, like the blubber on certain marine animals. This indicates that horned larks have plenty to eat, and that their food is largely carbonaceous. The necessity for such heat-producing food does not exist in the case of the California horned larks, but nevertheless they eat the same substances as those in a colder climate, although probably in reduced quantities.

The food of this bird consists largely of seeds picked up from the ground. Very naturally a bird that subsists on scattered seeds would pick up kernels of grain if they came in its way, and some persons have declared that this bird does serious damage to newly sown grain. As they sometimes associate in immense flocks, they may do harm when large numbers alight on a field before the grain has been harrowed in. Drilling the grain, which is the modern method, will obviate this trouble. Most of the grain eaten by these larks is waste from the harvest field.

For the investigation of the food of the horned larks of California, 259 stomachs, collected in every month except May, were available. While very irregularly distributed through the year, they probably give a fair idea of the annual food. In the analysis of the contents of these stomachs, approximately 9 percent of animal food was found to 91 percent of vegetable.

Animal food.—The horned lark is essentially a vegetarian, but eats a considerable number of insects during the reproductive season and feeds many to the young. Most of the animal food was taken between March and June, inclusive. The latter has the highest record, nearly 30 percent. As this lark is an early breeder, it begins eating insects early in the season. After June there is a rapid decrease in animal food, and the stomachs taken in November contained none whatever.

For convenience this part of the diet may be divided into the two items, beetles and other insects. Beetles amount to about 5 percent. Like the animal food in general, they were found in greatest quantities in the stomachs taken from March to June, the latter month showing a little over 20 percent. While a few predaceous ground beetles were eaten, the great bulk of these insects were of harmful species, among which were some snout beetles or weevils. The remainder of the animal food, 4 percent, consisted of bugs, ants, caterpillars, and a few miscellaneous insects and spiders. Of these, the greater number are either harmful or neutral.

Vegetable food.—The great interest in the food of the horned lark centers about the vegetable part. This consists of grain and weed seed. Corn was found in only one stomach. Wheat was contained in 21 stomachs, taken in four months: January, February, June, and July. The irregularity in eating grain would seem to indicate that it is not a favorite food. The midsummer records may be explained on the ground that these are the harvest months in California. But it is not supposable that wheat could be obtained in January and February and not in December or March. The greatest amount was eaten in February, 74 percent, but only 5 stomachs were taken in this month, and probably a greater number would have given a lower percentage. The average for the year is 9 percent. Of all the grains, however, oats are the favorite with the horned larks, as they are with so many other seed-eating birds. They were eaten much more regularly than wheat and in greater quantities. They were found in 142 stomachs, and November gives the highest record, 77 percent, while June has the lowest, a little over 8 percent. The average for the year is 31 percent. If all these oats were taken from the farmer's crop it might be a serious tax, but evidently only a few of them are so obtained. Those eaten in March may have been from newly sown fields, and those in June and July from the ripening crop, but the rest must have been waste grain gleaned from the fields, Moreover, California is covered with wild and volunteer oats, which, ripening at other times than the cultivated ones, furnish an inexhaustible supply of food for many birds. It is certain that most of the oats eaten by the California horned larks are either waste or volunteer grain, and have no economic value.

The particular food of horned larks is the seeds of weeds and grasses. These aggregate 51 percent of the annual diet, being eaten in every month, and constitute a respectable percentage of the food in each. The month of least consumption is January, when they amount to over 19 percent; August shows the maximum quantity, nearly 99 percent, but as only 4 stomachs were taken in this month, probably ample material would reduce this high percentage. It is by the consumption of weed seed that the horned lark makes amends for doing a little damage to grain. The quantity of seeds of noxious weeds destroyed annually by this species throughout the country is very great. Fruit does not appear in the stomachs of horned larks. The bird asks nothing of the orchardist—not even the shelter of his trees.

SUMMARY.

In the final analysis of the food habits of the horned lark there is but one tenable ground of complaint, namely, that it does some damage to newly sown grain. This can be largely remedied by harrowing in immediately after sowing, and can be wholly prevented by drilling. The bird's insect diet is practically all in its favor, and in eating weed seed it confers a decided benefit on the farmer. It should be ranked as one of our useful species, and protected by law and by public opinion.[a]

JAY FAMILY.

The jays have acquired a questionable reputation owing to the fact that they pilfer the nests of other birds and prey upon the farmer's crops. That at times they are guilty of both of these sins can not be denied. On the first of these counts the California jay is far more culpable than its eastern relative and does entirely too much nest robbing for the best interests of the State. It is also a despoiler of fruit in its season, and in this respect should be restrained. On the other hand, jays are conspicuous and ornamental elements in the bird fauna, and inasmuch as they consume many harmful insects, should not be wholly condemned.

Some half dozen species and subspecies of jays occur in California. The food of the two most important species is discussed in the following pages.

STELLER JAY.

(*Cyanocitta stelleri frontalis* and *carbonacea.*)

The Steller jay inhabits the mountains and forested areas of California throughout the year. It sometimes ventures to the edges of the valleys and occasionally visits orchards for a taste of fruit, of which it is very fond, but in general it keeps to the hills and wilder parts of the canyons. It is fond of coniferous trees and is likely to be found wherever these abound. Where ranches have been established far up the canyons among the hills, this jay visits the ranch buildings. While it has all the characteristics of the jay family, it is rather more shy than either the California jay or the eastern bluejay.

To determine the nature of the food of this species, 93 stomachs were available. They were distributed over the whole year except February and April. The contents consisted of animal food to the extent of 28 percent, and vegetable matter 72 percent.

Animal food.—Beetles amount to a little more than 8 percent: Carabidæ were found in 8 stomachs; all the others were of noxious species. One stomach was half filled with a species of weevil or snout beetle (*Thricolepis inornata*), of which 35 individuals were counted, and there were probably more. Hymenoptera amount to about 11 percent and are the largest item of animal food. They were found in 30 stomachs altogether, and 2 were entirely filled with them. Ants were found in only 2 stomachs. Three honey bees were identified, one in each of 3 stomachs. One was a worker, another a drone, and the third indeterminate. None of the smaller parasitic Hymenoptera were identified. The greater part of this item of food consisted of wasps and wild bees, which would indicate that this bird is an energetic and expert insect catcher.

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[a] For a more complete account of the food habits of the horned lark, see Bulletin No. 23, Biological Survey, U. S. Department of Agriculture, The Horned Larks and their Relation to Agriculture, by W. L. McAtee, 1905.

Hemiptera (bugs) are evidently not in favor with the Steller jay. They were found in but few stomachs and in small numbers and amount for the year to little more than 1 percent. Pentatomidæ, or stinkbugs, and Scutelleridæ, or shield bugs, were the only families identified. Diptera form only four-tenths of 1 percent. They were found in only 3 stomachs, taken at the same place and at the same hour. They consisted of crane flies (Tipulidæ) filled with eggs.

Orthoptera (grasshoppers and crickets) aggregate about 3.5 percent. They appeared in 28 stomachs and were the sole contents in one. Caterpillars and moths amount to a little more than 2 percent. The former were found in 17 stomachs and the latter in 2.

The following insects from the stomachs of the Steller jay were identified:

COLEOPTERA.

Sinodendron rugosum.
Dichelonycha fulgida.
Clerus sphegus.
Thricolepis inornata.

HYMENOPTERA.

Apis mellifera.

Of miscellaneous creatures, spiders were identified in 3 stomachs, raphidians in one, and sow bugs (*Oniscus*) in one; altogether they make up about one-half of 1 percent. Remains of vertebrates amount to a little more than 1 percent. They consist of hair and skin of a mammal found in one stomach, two bits of bone, probably of a frog, in one, and eggshells in 13. This last item is the worst in this jay's record, since it indicates that the bird is guilty of eating the eggs of smaller birds; but even this is not as bad as it looks. Only 6 of these egg-eating records occurred in June, the nesting month. All the rest were in September or later and were probably old shells picked up in abandoned nests or about ranch buildings or camp grounds.

Vegetable food.—The vegetable food may be divided into fruit, grain, mast, and miscellaneous matter. Fruit amounts to 22 percent and was found in 55 stomachs. Prunes were identified in 2 stomachs, cherries in 2, grapes in 2, Rubus fruits in 15, strawberries in 1, elderberries in 15, bay laurel fruit in 1, unknown wild fruit in 2, and fruit pulp, not fully identified but thought to be of cultivated varieties, in 16 stomachs. Thus 38 stomachs held fruit supposed to be cultivated. This number includes all containing Rubus fruits, which probably were not all cultivated—perhaps none of them were. The Steller jay undoubtedly eats considerable fruit, but most of its range lies in unsettled areas, and it is too shy to visit orchards, except those close to the timber. For the present, then, or until it becomes more domestic, the damage to cultivated fruit is likely to be small.

Grain amounts to 5 percent, and was found in 15 stomachs, distributed as follows: Wheat in 7, oats in 9, and barley in 1. Much of the wheat was damaged, and, in fact, owing to the times of year, it could not have been otherwise. The greatest amount of grain was taken in June, 24 percent, and was probably picked up in the harvest field. Many of the oats, perhaps all, were of the wild variety. The chief food of this jay, however, is acorns, though occasionally it eats other nuts or large seeds. Mast amounts to 42.5 percent of the yearly diet, and was found in 38 stomachs. In some of them it reached 99 percent of the contents. In October and November it amounted to 76 percent, in December to 90, and in January to 99 percent. Even in June, when other food was abundant, it was eaten to the extent of nearly 10 percent, though none was found in the stomachs taken in May or July. Very likely a considerable part of this was stolen from the stores of the California woodpecker, for it is hardly probable that the jays find acorns under the trees so late as June and so early as August. It is true the jays themselves store up nuts to some extent, but hardly on the scale indicated by the contents of their stomachs when the acorn harvest is long past. Seeds, galls, and miscellaneous matter make up the remainder of the vegetable food, about 2.5 percent. In two stomachs taken near the ocean were tangles of confervæ and other seaweeds.

SUMMARY.

From the foregoing analysis it will be seen that the food of the Steller jay is of minor importance from an economic point of view. In destroying beetles and Hymenoptera it performs some service, but it destroys only a few. Of the order of Hemiptera, which contains most of the worst pests of the orchardist and farmer, it eats scarcely any. The Orthoptera, which are almost all harmful insects, are eaten only sparingly, and the same applies to the rest of the insect food. The destruction of birds' eggs is the worst count against the jay. But none were found, except in June, until September, when it was too late in the season for fresh eggs to be obtainable. In June 17 birds were taken, and 6 of them, or 35 percent of the whole, apparently had robbed birds' nests. Now, it is evident that if 35 percent of all the Steller jays in California each rob one bird's nest every day during the month of June the aggregate loss is very great.

So far as its vegetable food is concerned, this bird does little damage. It is too shy to visit the more cultivated districts, and probably will never take enough fruit or grain to become of economic importance. The other vegetable food it consumes is entirely neutral from the economic standpoint.

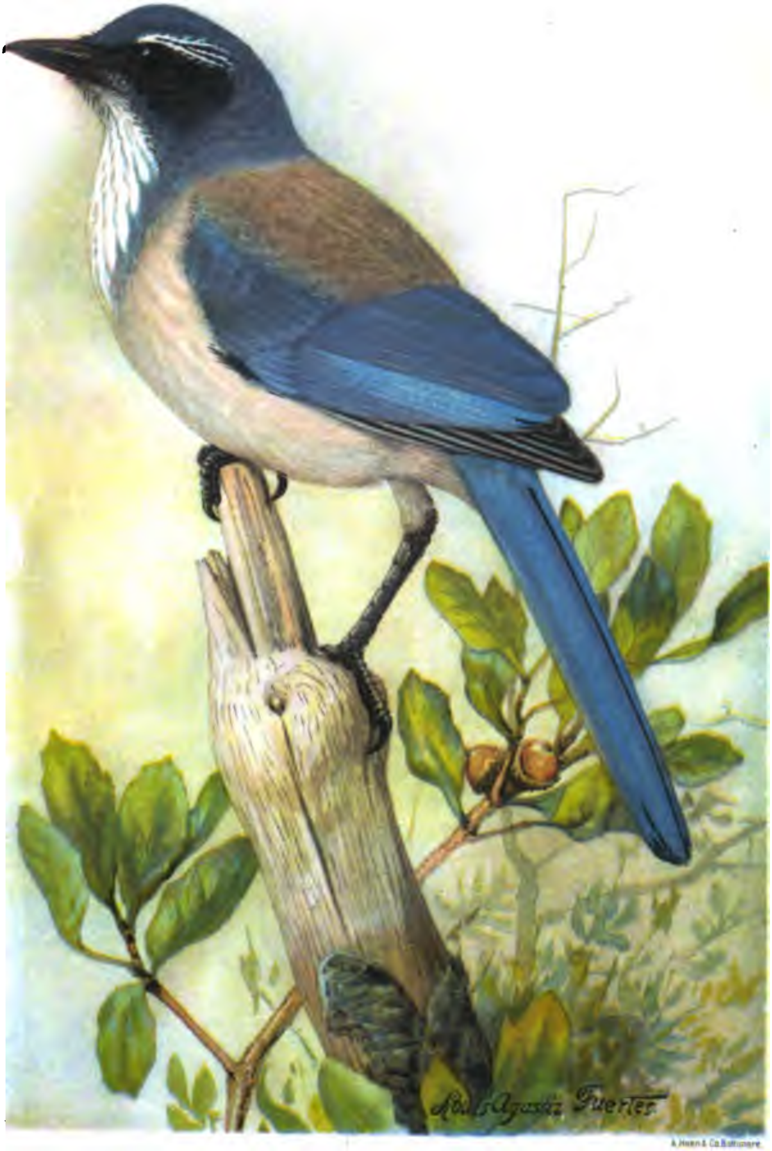
CALIFORNIA JAY.

(*Aphelocoma californica.*)

The California jay (Pl. III) occupies the warm chaparral-covered lower slopes of the Sierra Nevada and Coast ranges and adjacent valleys. He has the same general traits of character as the eastern jay, is the same noisy, rollicking fellow as that bird, and in California occupies a corresponding position in bird society. While for the most part a frequenter of woods and chaparral, he is by no means shy of visiting orchards and gardens, and will come even to the farm buildings if anything there interests him. A nest of the chipping sparrow (*Spizella passerina arizonæ*), which was being watched for notes on feeding, was robbed of its four nestlings early one morning by a jay, although not more than 30 feet from the front door of a house on the edge of the village. He is a persistent spy upon domestic fowls and well knows the meaning of the cackle of a hen. A woman whose home was at the mouth of a small ravine told the writer that one of her hens had a nest under a bush a short distance up the ravine from the cottage. A jay had found this out, and every day when the hen went on her nest the jay would perch on a near-by tree. As soon as the cackle of the hen was heard, both woman and bird rushed to get the egg, but many times the jay reached the nest first and secured the prize. A man living in the thickly settled outskirts of a town said that jays came every morning and perched on some large trees that overhung his barnyards, where the hens had their nests, and that it was necessary for some member of the family to be on the lookout and start at the first sound of the hen's voice or a jay would get the egg.

A still worse trait of the jay was described by a young man engaged in raising poultry on a ranch far up a canyon near wooded hills. When his white leghorn chicks were small, the jays would attack and kill them by a few blows of the beak, and then peck open the skull and eat the brains. In spite of all endeavors to protect the chicks and to shoot the jays, his losses were serious.

As a fruit-eater the jay has few equals. He has a pronounced taste for cherries and prunes, and where orchards of these fruits are near natural coverts, he will work unceasingly to carry off the fruit. The writer remained in a cherry orchard in such a situation from 9 a. m. to 4 p. m. on several occasions during the cherry season, and there was not an hour of that time that jays were not going away with fruit and coming for more, in spite of the fact that every one was shot that was unwary enough to give the collector a chance. A small prune orchard on some bottomland, just where a small ravine debouched from the wooded hills, was also watched. The fruit was just ripening, and a continuous line of jays was seen pass-



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CALIFORNIA JAY

ing from the hills down through the ravine to the orchard, while a return line, each jay bearing a prune, was flying up the ravine to the woods, where, probably, the fruit was secreted and left to rot. The jay habitually stores nuts and grain for future use, and no doubt, urged by a misdirected instinct, lays up fruit for the same purpose, but with a different result. Several hours later the jays were still at work. On another occasion 7 jays were shot successively from a prune tree loaded with fruit, and others continued to come, unterrified by the report of the gun or the dead bodies of their comrades that lay on the ground beneath the tree.

The jay is also a notorious pilferer of nuts, notably almonds and English walnuts. He is a skillful nutcracker, and extracts the kernel deftly by holding the nut between his feet on a branch, while he hammers it with his beak until he cracks the shell. Only the hardest nuts defy his powers. A gentleman who owned a large ranch situated in a canyon and on the surrounding hills planted a dozen or more almond trees to raise nuts for home use. When the trees came to bearing, the jays each year carried all the nuts away before they were ripe. "Although," said the owner, "the trees bear a fair crop, I never get a nut; the jays take them all." Another gentleman had a number of very large English walnut trees on his ranch, which was at the upper end of a wooded canyon. While these nuts were yet unripe, the jays destroyed a great many. Fortunately, when mature, they seem to be too hard for the jays to peck through, so the bulk of the crop was saved.

But the jays do not frequent orchards entirely for fruit. During May and June the writer many times visited an apple orchard, the leaves of which were badly infested with a small green caterpillar, locally known as the canker worm. When a branch is jarred, these insects let themselves down to the ground on a thread spun for the purpose. Many jays were seen to fly into the orchard, alight in a tree, and then almost immediately drop to the ground. Observation showed that the caterpillars, disturbed by the shock of the bird's alighting on a branch, dropped, and that the birds immediately followed and gathered them in. These caterpillars were found in the stomachs of several jays, in one case to the extent of 90 percent of the contents.

For the laboratory investigation of the food of the California jay, 326 stomachs were used. They were distributed through every month, but the greater number were taken from May to September, inclusive. As many of them as possible were collected about orchards, gardens, ranch buildings, and stock yards. In the first analysis the food divides into 27 percent of animal matter and 73 percent of vegetable. The greatest percentage of animal food occurs in April, when it reaches 70 percent. After that it decreases gradually to

January, when it falls to its minimum of a little less than 5 percent. Vegetable food, on the contrary, is most sparingly eaten in April and most abundantly in January.

Animal food:—As the jay is largely a ground feeder, careful account was kept of the predaceous ground beetles (Carabidæ). In May they amount to 10 percent of the food and to nearly as much in February; but in the other months they are insignificant. The total for the year is 2.5 percent. Other beetles, all either harmful or neutral, amount to a little more than 8 percent. They are eaten rather irregularly through the year. April shows the greatest consumption, nearly 31 percent, and January the least, only a trace.

Hymenoptera, in the shape of wasps, bees, and ants, amount to a little less than 5 percent. They were contained in 189 stomachs and were distributed as follows: Honey bees in 9, ants in 27, other Hymenoptera in 159. These figures illustrate the fact that a bird will eat a certain article of food very often, but in small quantities. While Hymenoptera amount to less than 5 percent of the food, they were found in nearly 58 percent of the stomachs. The honey bees, 20 in number, were found in 9 stomachs, and, what is very singular, all were workers. Birds that eat honey bees usually select the drones, but the jay appears to have chosen the workers. Fortunately he does not appear to eat many.

Hemiptera were eaten to the extent of less than one-half of 1 percent. One stomach contained 2 black olive scales (*Saissetia oleæ*). Diptera seem even less acceptable than bugs as an article of food. In July, the month of greatest consumption, there were less than 1 percent.

Lepidoptera (moths and caterpillars) amount to 2.5 percent. They were eaten in every month, mainly in the caterpillar stage. May was the month when the greatest number was eaten, nearly 10 percent. The most interesting point, however, in connection with this item of food is that 12 pupæ of the codling moth were found distributed through 8 stomachs. This is a most unexpected service from a bird of the jay's habits, and it may be said that a little work of this kind will cover a multitude of sins in other directions.

Orthoptera (grasshoppers and crickets) are eaten to the extent of 4.5 percent. Most of them were taken in July, August, and September. As usual, August stands first, with a consumption of nearly 17 percent, and one stomach contained the remains of 41 individuals. *Melanoplus devastator* was the only species identified. As the jay is, to a great extent, an inhabitant of the woods, it was natural that its stomach should contain quite a number of the brown wood cricket. A mole cricket also was found in one stomach. Orthoptera were found in 151 stomachs and formed the total food in one. When they are eaten so often, it is surprising that they do not form a larger percentage of the food.

A few miscellaneous creatures, such as raphidians, spiders, snails, etc., form less than one-half of 1 percent of the food.

The following is a list of insects identified in the stomachs of the California jay:

COLEOPTERA.

Amara conflata.
Silpha ramosa.
Limonius fulvipes.
Perothops witticki.
Onthophagus sp.
Diabrotica sp.
Coniontis robusta.
Blapstinus rufipes.
Sciopithes obscurus.
Balaninus sp.

HEMIPTERA.

Sinea diadema.
Saissetia oleæ.

HYMENOPTERA.

Apis mellifera.

LEPIDOPTERA.

Carpocapsa pomonella.

ORTHOPTERA.

Melanoplus devastator.

Besides the insects and other invertebrates already discussed, the jay eats some vertebrates. The remains consisted of bones or feathers of birds in 8 stomachs, eggshells in 38, bones of small mammals (mice and shrews) in 11, and bones of reptiles and batrachians in 13 stomachs. In destroying small mammals the jay is conferring an unmixed good, as practically all of them are injurious. His appetite for reptiles and batrachians, however, is unfortunate. These creatures, being mostly insectivorous, are very useful. Probably, however, their ranks are not seriously thinned by the jay. Of those eaten, 9 were lizards, one a snake, one a frog, and 2 others were batrachians, but could not be further identified. The great interest in the jay's vertebrate food, however, centers about the remains of birds and eggs. Of the 46 stomachs containing these remains, 17 were taken between the middle of May and the middle of July, and, as this period practically covers the nesting season in California, all may be considered as from the nests of wild birds robbed by the jay. The others represent either the eggs of domestic fowls or old eggshells. In the above period 95 stomachs were collected, of which 17, or 18 percent, contained eggs or remains of young birds. If we may infer, as seems reasonable, that 18 percent of the California jays rob birds' nests every day during the nesting season, then we must admit that the jays are a tremendous factor in preventing the increase of our common birds. Mr. Joseph Grinell, of Pasadena, after careful observation, estimates the number of this species in California at about

126,000. This is probably a low estimate. If 18 percent of this number, or 22,680 jays, each robs a nest of eggs or young daily for a period of sixty days from the middle of May to the middle of July, the total number of nests destroyed in California by this one species every year is 1,360,800. These figures are somewhat startling, representing as they do an enormous number of useful birds, and it is to be hoped they exaggerate the damage. For the present, however, they must stand for what they are worth. More data are necessary in order to determine fully the accuracy of the figures. Little weight attaches to the destruction of the eggs of domestic fowls by this jay, since in most cases it is easily preventable.

Vegetable food.—Aside from a few miscellaneous items, that altogether amount to less than 1 percent, the jay's vegetable food may be classed under three heads: Grain, fruit, and mast. Owing to the economic importance of this food the full tabulation is given below:

Month.	Grain.	Fruit.	Mast (acorns).	Month.	Grain.	Fruit.	Mast (acorns).
January	9.40	9.00	74.90	August	18.73	48.53	0.21
February	6.43	....	69.14	September	24.26	19.89	31.65
March	45.50	....	27.00	October	.29	....	88.57
April	5.00	....	24.75	November	....	11.14	66.29
May	2.43	61.41	.68	December	....	17.50	73.00
June	10.27	51.29	2.22				
July	18.42	44.94	.19	Average.	11.73	22.05	38.22

It will be seen that March holds the highest record for grain. This was probably picked up from fields newly sown. After that, not much is eaten until June, when the harvest begins. From that time on, grain is an important article of diet, and is obtained by gleaning in the harvested fields. It makes a sudden drop at the end of September, for at that time the acorn crop comes in. Grain was found in 95 stomachs, of which 56 contained oats; 34, corn; 2, wheat; 2, barley; and 1, grain not further identified. Many of the oats were of the wild variety.

Fruit was found in 270 stomachs. Of these, cherries were identified in 37, prunes in 25, apples in 5, grapes in 2, pears in 2, peaches in 1, gooseberries in 2, figs in 1, blackberries or raspberries in 71, elderberries in 42, manzanita in 4, cascara in 1, mistletoe in 1, and fruit pulp not further identified in 76. It will be noted that most of the fruit was eaten in the five months from May to September, inclusive. All found in November, December, and January was fruit pulp without seeds, evidently old fruit left on the trees. All the small fruits, as raspberries and elderberries, were taken during the summer months. The raspberries may have been either wild or cultivated, and were probably both; but in any case it is safe to say that half of the fruit eaten was of wild varieties and of no economic value.

Mast forms the largest item of the jay's food. This fact has some economic interest, since mast possesses considerable value as food for stock, especially hogs. A glance at the table will show the high percentages for the eight months from September to April inclusive, and then the sudden drop to the low rank it holds for the rest of the year. While the average consumption for the year is 38 percent, for these eight months alone it rises to nearly 57 percent, or more than half of the whole food. Doctor Merriam says that by the Indians this jay is called the oak planter. There is no doubt that all jays unconsciously aid in planting forest trees. Like the California woodpecker they habitually store up nuts and other large seeds, though unlike that bird they do not prepare storage places, but place them in forks of trees, cracks in old stumps or logs, behind loose pieces of bark, or bury them in the ground. Nuts are often dropped when being carried to a place of concealment, and sprout and grow to renew the forest.

SUMMARY.

The insect food, though small in amount, may be set down to the jay's credit. By the destruction of birds' eggs and young, it does serious mischief. Two items of its vegetable food, grain and fruit, are against the jay. In the case of grain, however, it is doubtful if much damage is done, since it is taken mostly after the harvest. If the grain taken in early spring is stolen from newly sown fields, it represents a real loss; but the jay is not known to pull up grain after it has sprouted, so that all it gets at this time must have been left uncovered, and is therefore of minor importance. After harvest it is common to see small companies of jays in fields, where they probably glean scattered kernels as well as some insects. In the matter of fruit stealing there are no extenuating circumstances. Wherever orchards are near its haunts, the jay is a persistent and insatiable fruit thief. If he took only what is necessary to satisfy the appetites of himself and family, he might be endured for the sake of his better traits. But long after his hunger is appeased, he continues to carry off fruit to store away, and thus his pilferings are limited only by his numbers and by the size of the fruit crop. Moreover, much of the fruit which he pecks is left on the tree to rot, and more falls to the ground unfit for use, except by pigs. It is fortunate that only orchards situated near the jay's usual haunts suffer severely. Those farther away are visited occasionally, but are not seriously damaged. Unlike many other birds which prey upon the earlier fruits, the jay continues his depredations as long as fruit is to be had. In an orchard closely watched by the writer it was found that when the earlier cherries were ripening, blackbirds, thrushes, orioles, grosbeaks, cedar birds, and linnets, as well as jays, were present in numbers, but two weeks later, when the earlier varieties were gone and the later ones were ripe, hardly any smaller birds were present, while the jays were as busy as ever; and still later, at the end of the season, when the prune crop came on, jays were still taking a heavy toll.

It will thus be seen that the jay has many more bad qualities than good. In fact, from the economic point of view he has few redeeming virtues. Something may be said in his favor from the esthetic side, as he is a handsome bird, and people interested in country life would no doubt miss his familiar presence. But as the case stands there are far too many California jays. If they could be reduced to a fourth or a half of their present numbers, the remainder would probably do no serious harm. This is exactly what is likely to take place gradually as the State becomes more thickly settled and forest and chaparral lands decrease.

BLACKBIRD, ORIOLE, AND MEADOWLARK FAMILY.

(*Icteridæ.*)

The family which includes the orioles, blackbirds, and meadowlarks embraces species widely different in form, plumage, nesting habits, and food. The orioles nest in trees and obtain the greater part of their food thereon. The blackbirds nest upon low trees, bushes, or reeds, and take their food from trees to some extent, but mostly from the ground. The meadowlarks, the most terrestrial of all, nest upon the ground and obtain nearly all of their food there. Orioles eat the greatest percentage of insects, the meadowlarks eat a little less, while the blackbirds eat the least. Blackbirds rank next to sparrows as eaters of weed seeds, especially in winter.

Besides the Brewer blackbird there are in California 5 species and subspecies of redwinged blackbirds, which are so much alike that most of them can be distinguished only by ornithologists. All have practically the same nesting habits, and their food is not essentially different.

BICOLORED REDWING.

(*Agelaius gubernator californicus.*)

The bicolored redwing is distributed locally over a large part of California, but owing to its peculiar habit of building its nest directly over water, the areas it occupies are restricted. Flooded marshes and ponds overgrown with bulrushes or tules are much to its taste, affording abundant nesting sites. Such places are common in California and many are of large extent—as those on Suisun Bay and in the Sacramento and San Joaquin valleys. Among these the bicolored redwing and his redwinged relatives find congenial quarters.

For the laboratory investigation of the food of this species, 198 stomachs were available. They were collected in every month of the year, and probably give a fair idea of the bird's food. It was found to consist of 14 percent of animal matter to 86 of vegetable. The animal food is practically all insects, and the vegetable either grain or weed seed.

Animal food.—Most of the animal food was taken in May, June, and July. May stomachs showed the maximum of nearly 91 percent. There is a sudden rise in the amount from April to May and a sudden fall from July to August. The insects composing this part of the food were distributed among several of the most common orders, but none of them appear to be specially sought after. Beetles aggregate about 5 percent. A few were predaceous ground beetles, but the most were either leaf beetles (Chrysomelidœ) or weevils. Hymenoptera, in the shape of wasps and ants, were taken very sparingly in the four months from May to August inclusive, and amount to about one-fourth of 1 percent for the year. Bugs were eaten during the six warmer months, and for the year aggregate just 1 percent. Grasshoppers constitute over 15 percent of the food in July. They are a fraction of 1 percent for the other months and average 1.5 percent for the year.

Caterpillars aggregate 5.5 percent, the highest of any item of animal food. In May they amount to over 45 percent of the food of that month, which is more than for all the other months together. Probably they are fed largely to the nestlings, as a few taken in May had eaten a large percentage of these insects. It is worthy of special notice that the caterpillar known in the cotton-raising States as the cotton bollworm, and elsewhere as the corn-ear worm, *Heliothis obsoleta*, was found in 7 stomachs. This is certainly to the credit of the bird, and it may be that its visits to cornfields are for this insect primarily, and that corn is taken only incidentally. A few miscellaneous insects amount to less than 1 percent and complete the animal portion of the diet.

The following are the insects identified in stomachs of the bicolored redwing:

COLEOPTERA.

Elaphrus ruscarius.
Gastroidea cyanea cæsia.
Chætocnema minuta.
Systena ochracea.
Notoxus alamedæ.
Apocrypha dyschirioides.

LEPIDOPTERA.

Heliothis obsoleta.

Vegetable food.—Two prominent constituents make up the vegetable food of the redwing—grain and weed seed. Grain amounts to 70 and weed seed to 15 percent. The grain consists of corn, wheat, oats, and barley. Oats are the favorite. They amount to over 47 percent of the yearly food, and were eaten in every month except February, when they were replaced by barley. The month of maximum consumption was December, when nearly 72 percent was eaten, but several other months were nearly as high. Wheat stands next to oats in the quantity eaten, nearly 13 percent. It is taken quite regularly in every month except March and May. Barley was found only in stomachs taken in February, October, and November, and nearly all of it was taken in February. The average for the year is 5.5 percent. Corn is eaten still less than barley, and nearly all was consumed in September, when it reached nearly 46 percent of the month's food. A little was eaten in May, August, and October, but the aggregate for the year is only slightly more than 4 percent.

Weed seed amounts to 15 percent of the food of the bicolored redwing. It is eaten in every month except May, when it gives way to animal food. The following species were identified:

Sunflower (*Helianthus* sp.).
Tarweed (*Madia sativa*).
Bur clover (*Medicago denticulatum*).
Alfilaria (*Erodium cicutarium*).
Red maids (*Calandrinia menziesi*).
Pigweed (*Amaranthus retroflexus*).
Chickweed (*Stellaria media*).
Catchfly (*Silene* sp.).
Smartweed (*Polygonum*).
Sorrel (*Rumex* sp.).
Canary seed (*Phalaris caroliniana*).
Sedge (*Carex* sp.).

These seeds were eaten very regularly throughout the year. The greatest consumption is in March, 35 percent, but as the record for several other months does not fall much below, probably this has no special significance. All of the above weeds are more or less of a nuisance, though at times some of them may be used as forage plants. Fruit is not eaten by the bicolored redwing.

Food of young.—Among the stomachs of the bicolored redwing were 11 of nestlings varying in age from 4 days to 2 weeks. The food was made up of 99 percent of animal matter and 1 percent of vegetable, though most of the latter was mere rubbish, no doubt accidental. Caterpillars were the largest item, and amounted to an average of 45 percent. Beetles, many of them in the larval state, stood next, with 32 percent. Hemiptera, especially stinkbugs and leafhoppers, amounted to 19 percent. A few miscellaneous insects and spiders made up the other 3 percent. It will be noted that the food of the young is practically all animal and that a preponderance of caterpillars and beetle larvæ makes it softer than that of the adults.

SUMMARY.

In summing up the facts relating to the food of the bicolored redwing, the most prominent point is the great percentage of grain. Evidently if this bird were abundant in a grain-raising country it would be a menace to the crop. But no complaints of the bird's depredations on grain have been made, and it is significant that the grain consumed is not taken at or just before the harvest, but is a constant element of every month's food. As the favorite grain is oats, which grows wild in great abundance, it must be admitted that, with all its possibilities for mischief, the bird at present is doing very little damage. So far as its insect food goes, it does no appreciable harm and much good. Its consumption of weed seed is a positive benefit. Like the other redwings, it has interesting habits and a pleasant song, and for the present, at least, should be protected.

OTHER REDWINGS.

In addition to the stomachs of the bicolored redwing, a few of 2 other species of redwings have been examined. They comprise 16 stomachs of the tricolored redwing (*Agelaius tricolor*), and 12 of the western redwing (some form of *A. phœniceus*). From the examination of so small a number, final data on the food can not be obtained, but so far as the testimony goes, it indicates that both species consume more insects and less grain than the bicolored. The stomachs of the tricolored contain 79 percent of animal matter to 21 of vegetable. The animal matter consists mostly of beetles and caterpillars, with a decided preponderance of caterpillars. The vegetable food is nearly all weed seed. One stomach alone contained barley.

In the case of the western redwings, the animal food amounted to 63 percent to 37 of vegetable. The former was pretty evenly distributed among beetles, grasshoppers, and Lepidoptera (moths and caterpillars), and contained in addition a few aquatic insects. The vegetable food was largely weed seed. A little barley was found in one stomach, and one was filled with oats.

It is evident from the foregoing that the beneficial greatly outweigh the injurious elements in the food of these redwings.

BREWER BLACKBIRD.

(*Euphagus cyanocephalus.*)

The Brewer blackbird (Pl. IV) occurs over most of the cultivated districts of California. By choice it is a resident of fields, meadows, orchards, and about ranch buildings and cultivated lands generally. It takes the place on the Pacific coast occupied by the crow blackbird (*Quiscalus quiscula* and *æneus*) in the Mississippi Valley and farther east, and is so similar in appearance and habits that the eastern observer in California forgets that it is not the same species. It nests in bushes, weeds, and sometimes in trees, and is so gregarious that several nests are often built in the same vicinity. Large colonies frequently establish themselves near farm buildings, and feed freely in the stock yards and cultivated fields. When fruit is ripe these blackbirds do not hesitate to take a share, and they visit the orchard daily for the early cherries.

They claim a share of grain also, but do not appear to eat it at harvest time so much as afterwards. Mr. Walter K. Fisher, writing from Stockton, Calif., on November 12, 1897, reports them as feeding on newly sown wheat that had not been harrowed in, eating nearly all thus left exposed. He describes the birds as in such immense flocks in the grain fields that at a distance they looked like smoke rising from the ground, and says that stomachs of birds taken were full of wheat. On the other hand, Prof. A. J. Cook, of Claremont, Calif., says that he considered it one of the most valuable species in the State; and Mr. J. F. Illingsworth, of Ontario, Calif., in a paper read before the Pomona Farmers' Club,[a] speaks of it as a beneficial bird, which should be protected. Mr. O. E. Bremner, State horticultural inspector, in a letter to the Biological Survey, says:

> The cankerworm episode is quite a common one with us here. In one district, Dry Creek Valley, Sonoma County, there has been a threatened invasion of the prune trees by spring cankerworms several times, but each time the blackbirds came to the rescue and completely cleaned them out. I have often seen bands of blackbirds working in an infested orchard. They work from tree to tree, clearing them out as they go. If a worm tries to escape by webbing down, they will dive down and catch him in mid-air.

During the cherry season the writer observed these birds in the orchards, and collected a number of them. They were seen to eat freely of cherries, and the stomachs of those taken showed that a goodly proportion of the food consisted of cherry pulp. While these observations were being made, a neighboring fruit raiser began to plow his orchard. Almost immediately every blackbird in the vicinity was upon the newly opened ground, and many followed within a few feet of the plowman's heels in their eagerness to get every grub or other insect turned out by the plow. On another occasion an orchard was being watched while the far side was being plowed. A continual flight of blackbirds was passing in both directions over the observer's head, and practically all of them alighted on the newly plowed ground, fed there for a while, and then returned, probably to their nests. When plowing was finished and harrowing began, the blackbirds immediately changed their foraging ground, and followed the harrow as closely as they had accompanied the plow.

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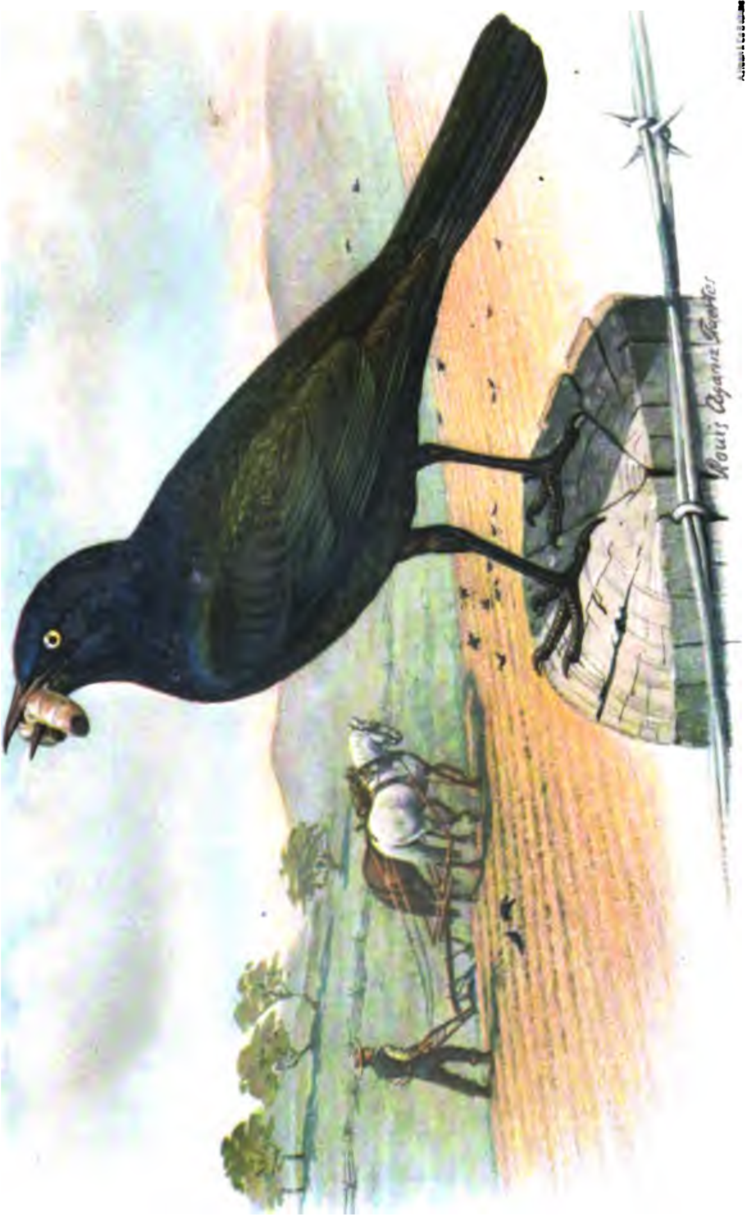
[a] Ontario Observer, June 3, 1899.



BREWER BLACKBIRD

In the laboratory investigation of this bird's food 312 stomachs were available. They were collected in every month in the year, and represent fairly the fruit and grain growing sections of the State from Santa Rosa southward. Many were taken in orchards and gardens when in the act of pilfering fruit or other products of husbandry. Besides adults, 29 nestlings of various ages are represented. The first analysis of the stomach contents gives 32 percent of animal matter to 68 of vegetable. The animal food consists of insects, spiders, sow bugs, snails, and eggshells.

Animal food.—The animal food attains its maximum in April, when it reaches 82 percent. From that time it slowly decreases until December, when it is only 5 percent, and then rises toward its maximum. The increase is very sudden from March to April. Beetles constitute over 11 percent of the food, and of these 2.5 percent are predatory ground beetles (Carabidæ). April is the month of greatest consumption of beetles, 29 percent, but no carabids are eaten in this month. In June 22.5 percent of beetles are eaten, of which 12 percent are carabids. The amounts eaten in other months are insignificant. The great bulk of the beetles eaten are the darkling beetles (Tenebrionidæ), which have much the same habit of living on the ground as the carabids, and are probably more abundant in California. One stomach was entirely filled with them. A few click beetles (Elateridæ) and some weevils were also eaten.

Hymenoptera (wasps, bees, and ants) were eaten to the extent of 1.7 percent of the food. Evidently blackbirds are too slow to catch often such agile creatures as wasps and bees. Hymenoptera were eaten in every month from March to November, inclusive. In June they amount to something over 7 percent, which is the maximum.

Bugs (Hemiptera) of various kinds are eaten from April to November to a small extent. They aggregate somewhat more than 1 percent for the year. In the month of greatest consumption, June, they reach only 5.5 percent. They belong mostly to the families of stinkbugs (Pentatomidæ) and shield bugs (Scutelleridæ). A black olive scale was found in one stomach. Flies (Diptera) were eaten to a slight extent from April to July inclusive, with a trace in October. The total for the year is only a little more than 1.5 percent. Like bees and wasps, flies are probably too quick to be easily caught.

Caterpillars and pupæ (Lepidoptera) reach the highest percentage of any item of animal food. They amount to nearly 12 percent, and are eaten in every month. April is the month when most are taken, over 38 percent, and the record for May stands nearly as high. They belong largely to the owlet moths (Noctuidæ), which comprise many of those pests generally known as cutworms. The cotton bollworm, or corn-ear worm (*Heliothis obsoleta*), was identified in 10 stomachs, and was probably contained in many more, but in a condition that baffled recognition. The most interesting Lepidoptera were the pupæ of the codling moth, found in 11 stomachs, 4 of which belonged to adults, while the other 7 were from nestlings, whose food will be discussed farther on. An orchardist told the writer that at one time his trees became infested with cankerworms, which swarmed all over the orchard and were rapidly destroying the leaves, when the blackbirds came in great numbers from all quarters and fed upon the worms until they were practically exterminated.

Grasshoppers and crickets were taken from April to November, inclusive, and amount for the whole year to 3.5 percent of the diet. In June they constitute over 15 percent of the food of that month, but only a moderate percentage was eaten in the other months. It is rather remarkable that birds which feed so much on the ground should eat so few of these insects, but this species appears to be mainly a vegetable eater, and to get the larger part of its animal food in April, just at its reproductive season, before grasshoppers are abundant.

Following is a list of insects identified in the stomachs of the Brewer blackbird:

COLEOPTERA.

Trixena scitula.
Trixena longula.
Bradycellus rupestris.
Scymnus lacustris.
Dermestes mannerheimi.
Saprinus obscurus.
Anchastus cinereipennis.
Aphodius rugifrons.
Aphodius granarius.
Diabrotica soror.
Diachus auratus.
Gastroidea sp.
Blapstinus pulverulentus.
Blapstinus rufipes.
Apocrypha dyschirioides.
Anthicus punctulatus.
Sitones sp.

HEMIPTERA.

Saissetia oleæ.

LEPIDOPTERA.

Heliothis obsoleta.
Carpocapsa pomonella.

Vegetable food.—The vegetable food reaches its maximum of 95 percent in December, when animal food is least plentiful. It may be divided into fruit, grain, and weed seed. Fruit was eaten in May, June, and July, not a trace appearing in any other month. It was found in 63 stomachs, of which 37 contained cherries (or what was thought to be such); 2, strawberries; 3, blackberries or raspberries; and 21, fruit pulp or skins not further identified. The percentages for each month were 14 for May, 22 for June, and 15 for July, an average of 17 percent for each of the three months, or of a little more than 4 percent for the whole year. This certainly is not a bad showing, and if the bird does no greater harm than is involved in its fruit eating, it is well worth protecting.

Grain constitutes 54 percent of the yearly food of the Brewer blackbird. It is eaten in every month, and forms a respectable percentage in each. The greatest amount is taken in December, 93 percent, and the least in April, 4 percent. Oats are the favorite grain. They amount to nearly 46 percent, and were found in 157 stomachs. Wheat amounts to nearly 3 percent, and was contained in 11 stomachs. Corn ranks next as to quantity eaten, less than 2 percent, but it was found in 17 stomachs. Barley occurred in only 5 stomachs, but amounted to a little more than 2 percent. Only 1 stomach held rye, but it amounted to more than 1 percent, for the stomach was nearly filled with it. Oats were the sole contents of 14 stomachs and wheat of 2. No stomach was completely filled with any other grain. Oats are evidently the favorite grain, whether we judge by the percentage eaten or by the number of stomachs containing them. Many of these were wild oats and of little economic value.

Weed seed amounts to nearly 9 percent of the food, and, while not consumed in large quantities, is eaten to some extent in every month. The greatest amount is taken in March, 26 percent. October comes next, with nearly 16 percent. The least is eaten in December and January, when grain is at its highest point. But little weed seed is eaten in May and June, when cherries demand attention. Weed seed was found in 134 stomachs, but in rather small quantities in each. No stomach was completely filled with it. It seems to be taken, moreover, rather irregularly, as though it were merely a makeshift. A few other odd items, mostly rubbish, amount to less than 1 percent, and complete the quota of vegetable food.

Seeds of the following uncultivated plants were identified:

Lesser tarweed (*Hemizonia fasciculata*).
Tarweed (*Madia sativa*).
Bur thistle (*Centaurea melitensis*).
Alfilaria (*Erodium cicutarium*).
Black mustard (*Brassica nigra*).
Miners' lettuce (*Montia perfoliata*).
Red maids (*Calandrinia menziesi*).
Pigweed (*Amaranthus retroflexus*).
Spurry (*Spergula arvensis*).
Chickweed (*Stellaria media*).
Catchfly (*Silene* sp.).
Knotweed (*Polygonum* sp.).
Brome grass (*Bromus* sp.).
Wild oats (*Avena fatua*).
Monterey pine (*Pinus radiata*).

Food of young.—Among the stomachs examined were those of 29 nestlings, varying in age from twenty-four hours to some that were nearly fledged. Taken altogether, the stomachs contained 89 percent of animal matter to 11 of vegetable. Over 74 percent of all was composed of caterpillars, grasshoppers, and spiders. Beetles in general amount to 6 percent of the food, or a little more than half the quantity eaten by the adults. Very singularly, however, 4.5 percent of these are carabids, or predatory ground beetles, nearly twice as many as are taken by the parent birds, although soft food is usually preferred for feeding nestlings. Caterpillars, with a few adult moths and some pupæ, aggregate 33 percent, which is three times as many as were eaten by the old birds. They were found in 22 of the 29 stomachs. The most interesting part of this item is 15 codling moth pupæ that were contained in 7 stomachs. Four adult stomachs also contained one each of these pupæ, but they seem to be mostly reserved as tidbits for the young. Grasshoppers and crickets were found in 21 stomachs, and aggregate 30 percent of the food, more than eight times as much as was eaten by the adults, so these insects also are evidently reserved for the nestlings. Spiders amount to 11 percent of the food of the young, although less than 1 percent of the parents' food. Various other insects and a few snails make up the rest of the animal food.

The vegetable food consists of fruit, grain, and rubbish. Fruit, probably cherries, was found in 4 stomachs of one brood. The average for each stomach was 43 percent. This was the oldest brood taken, and the birds were nearly ready to fly, which probably accounts for the large proportion of vegetable food. Oats, found in the stomach of one bird about a week old, amounted to about 45 percent of the contents, and seemed unusual food for so young a bird. The other two of the same brood had grass and other rubbish in their stomachs. Rubbish is the best term to describe the vegetable matter in most of these stomachs. The fruit and grain were all that should be called food.

One can not fail to notice the very pronounced difference in diet between these nestlings and the adults. Not only is the animal food of the young greatly in excess, but it is practically made up of spiders, caterpillars, and grasshoppers. All of these are comparatively soft-bodied creatures, and probably on that account are selected for the young.

SUMMARY.

In so far as its animal food is concerned, but little fault can be found with the Brewer blackbird. The insects eaten are fairly well distributed among the various orders, and include only a comparatively small number that are useful. As to fruit, no more is eaten than may be considered a fair return for the destruction of insects. The weed seed eaten must be set down to the bird's credit. All question, then, in regard to its economic position must rest upon the grain it eats. Most of the grain is taken in the months from August to February, inclusive. The average amount consumed in those seven months is over 75 percent of the food, while the average for the other five months is less than 24 percent, yet this last period covers the time from sowing to the end of harvest. As matters stand at present, probably the bird is doing no harm by eating grain, except perhaps under exceptional circumstances. It has a decided proclivity for oats, and if abundant would undoubtedly prove a menace to the crop.

WESTERN MEADOWLARK.

(*Sturnella neglecta.*)

Throughout California wherever grassy uplands, fields, and meadows occur, there will be seen the western meadowlark. Low, rich meadows, verging to marsh, with water near by, form ideal conditions for this bird. Nor does it disdain fertile hillsides when not too high, and when covered by a thick coat of herbage. Only professional ornithologists take note of the plumage differences between the eastern and western species of the meadowlark, but the difference in song is evident to the dullest ear. Owing to the snow, meadowlarks in the northern and eastern parts of the United States must migrate in winter far enough south to find open ground, but in California valleys no such necessity exists; so the bird remains on the same range the year round, and carries on its good work of destroying insects and weeds.

A few complaints have been made that meadowlarks in California eat the seeds of forage plants, notably clover, to an injurious extent. As most of the forage plants, including the introduced grasses of the Pacific coast lowlands, are annuals, the destruction of their seed would lessen the next season's feed and be a damage. Probably, however, such harm is done only under exceptional circumstances, for the stomachs show only a very small percentage of seed of forage plants and no clover seed. Another report is that the meadowlark does considerable damage to peas. The earliest fields are most visited by the birds, and small patches are sometimes almost completely destroyed. The later crops are not so badly damaged, and in extensive areas the loss is hardly noticeable. All the reports of damage to peas thus far received are from southern California, and very likely the explanation lies in some peculiar local conditions. The birds evidently lose their taste for this kind of food before the season is over, and probably find something more palatable which is wanting at first.

In some parts of the San Joaquin Valley the meadowlark has been accused, and probably with good reason, of pulling up sprouting grain in early spring. It is stated that the bird bores down beside the new plant and draws out the kernel. In many cases the amount of grain thus destroyed is said to be large. In one instance it was stated that the crop over a limited area was reduced 50 percent. The evidence, however, is conflicting, as some grain growers in the same localities are not aware of any loss. It thus seems probable that the damage to grain by the meadowlark is limited in extent and very local.

For the determination of the food of the meadowlark 91 stomachs were available, distributed throughout the year. The food consists of 70 percent of animal matter to 30 of vegetable. Broadly speaking, the animal matter is made up of insects and the vegetable of seeds.

Animal food.—Beetles are the largest item of the animal part of the diet. They are evidently a favorite food, for they are eaten in every month, with a good percentage in nearly all of them. The amount for the year is almost 27 percent. Practically half of this consists of the predatory ground beetles (Carabidæ). It is not surprising that the meadowlark should eat these beetles, for nearly all of them live on the ground, and walk and run much more than they fly; hence they are easily taken. As nearly all the species subsist largely upon other insects, their destruction must be considered as a flaw in this bird's record. All the other beetles eaten are harmful or neutral, and include a number of weevils. One stomach contained 36 yucca weevils (*Rhigopsis effracta*). The greatest number of beetles appears to have been eaten in March, when they amount to 72 percent, but as only two stomachs were available for that month the record is unreliable.

Wasps and ants (Hymenoptera) aggregate nearly 6 percent. They were eaten in every month but two, and ample material would undoubtedly show them in every month. Ants, being the more terrestrial, seem to be more natural food for the meadowlark than wasps or bees, but the bird gets a good share of both. Bugs (Hemiptera) were eaten to the extent of a little more than 4 percent. Nearly all of them were stinkbugs (Pentatomidæ). They were not eaten very regularly, and several months were not represented. May was the month of greatest consumption, 27 percent, but this may have been accidental.

Lepidoptera, largely caterpillars, aggregate about 15 percent. They were eaten in every month except August, when they were replaced by grasshoppers. February is apparently the month of maximum consumption, but a greater number of stomachs might prove differently. It is thought that many of these are of the kinds known as cutworms, though none were positively identified. All were undoubtedly terrestrial species, for the meadowlark is not known to seek food anywhere but on the ground.

Grasshoppers, when abundant, are usually eaten very freely by all ground feeding birds and by many arboreal species. The western meadowlark eats them to the extent of something more than 12 percent of its yearly food. This is a very small percentage for a bird of such terrestrial habits. The eastern form eats them to the extent of 29 percent, and in August the amount taken reaches 69 percent of the food of that month. With the western species the consumption reaches 42 percent in August, which is the maximum for the year. In the East the grasshopper season is limited to five months at most, but in California these insects can always be found. This makes it all the more surprising that California meadowlarks do not eat them more freely, but it is noteworthy that nearly every species of terrestrial bird in the East eats a larger percentage of these insects than does the related species on the Pacific coast. The actual percentage of grasshoppers proper eaten by the western meadowlark is even less than the above figures indicate, for the record includes quite a number of crickets, both the black and the brown or wood crickets (*Stenopelmatus*). One stomach contained 12 wood crickets. Crane flies (Tipulidæ), spiders, sowbugs (*Oniscus*), and a few snails make up the rest of the animal food, nearly 6 percent. More than half of this item consists of the crane flies (daddy longlegs) found in one stomach taken in April, in which they amounted to 45 percent of the stomach's contents.

The following insects were identified in the stomachs of the western meadowlark:

COLEOPTERA.

Calosoma externum.
Triæna longula.
Silpha ramosa.
Dolopius lateralis.
Taphrocerus gracilis.
Eurymetopon cylindricum.
Blapstinus dilatatus.
Rhigopsis effracta.
Sitones hispidulus.

ORTHOPTERA.

Stenopelmatus sp.

Vegetable food.—The vegetable food of the western meadowlark may be arranged under three heads: Fruit, grain, and weed seed. In one stomach taken in November was found something which was doubtfully identified as fruit pulp, but no other stomach contained a trace of fruit, and this bird has rarely been accused of eating fruit.

From August to March inclusive, grain is one of the most important articles of food. The average monthly consumption for the year is 27.5 percent, but for the eight months just indicated the average is 41 percent. In the other four months, that is, from April to July inclusive, which include the ripening and harvesting of the crop, no grain except a little corn was eaten. Grain of some kind was found in 60 of the 91 stomachs, and 4 were entirely filled with it. Corn is eaten only occasionally, and amounts to but 1 percent of the food. It was all taken in May and June. Wheat was eaten from October to January, inclusive. It amounts to over 11 percent for those months, but to less than 4 percent for the whole year. As is usual with grain eating birds, oats are the favorite kind. They were eaten from August to March inclusive, and average nearly 33 percent for those eight months, and for the year a little less than 22 percent. The greatest quantity, nearly 57 percent, was eaten in January, but nearly as much was taken in September. March, the month of seeding, shows the least, 10 percent. Barley was found in 6 stomachs taken in November, and amounts to less than 1 percent for the year.

Weed seed forms only 2 percent of the yearly food of the western meadowlark. With the eastern bird it aggregates a little more than 11 percent. It seems strange that a bird which obtains its food from the ground, and whose vegetable diet consists so largely of seeds, should neglect a food that furnishes sustenance to so many other species of birds. Weed seed was eaten so irregularly as to indicate that it was taken only as a makeshift. December was the month of greatest consumption, when it amounted to 15 percent.

SUMMARY.

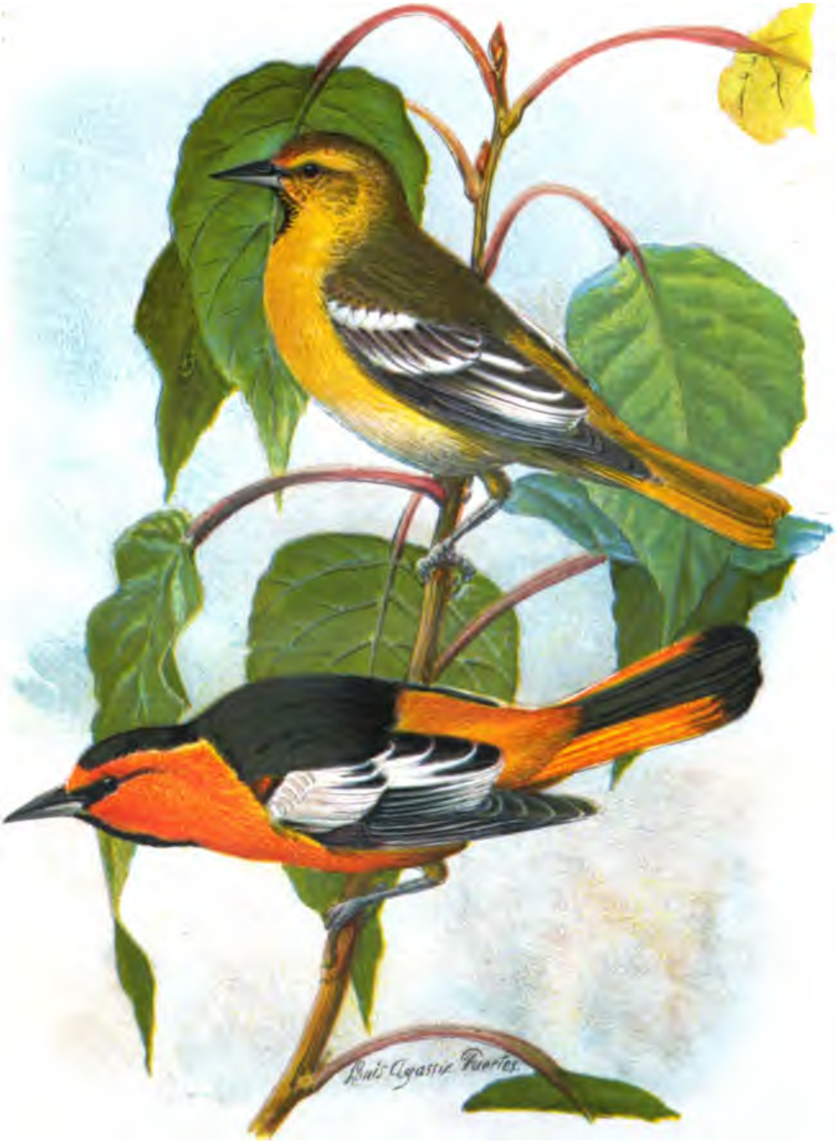
Three items of damage may be brought up against the meadowlark. The first is the destruction of predaceous ground beetles (Carabidæ), which amount to one-eighth of its food. This, however, constitutes but a small offense when we consider the number of caterpillars and grasshoppers which the bird also destroys. The damage to peas and grain when sprouting are undoubtedly real and in some cases serious, but the conflicting testimony in regard to these points indicates that this damage is due to local conditions, and it is probable that a careful study of the attendant circumstances will lead to a remedy.

In some communities, especially in the South and West, where meadowlarks are most abundant, there is a tendency to include them among game birds. The tiny body of the meadowlark, however, has slight food value as compared with the value of the living bird to the agriculturist. While the western meadowlark can not be classed in the front rank of the proved friends of the farmer, its services are sufficiently real and important to earn protection wherever it is found.

BULLOCK ORIOLE.

(*Icterus bullocki.*)

Over most of the plains and valleys of California, where trees are available for nesting and foraging, the Bullock oriole (Pl. V.) is a common summer visitant. In the West it takes the place occupied in the East by the Baltimore oriole. In food, nesting habits, and song the birds are similar. Both are migratory and remain on their summer range only about five or six months. They are rather domestic in habits, and take kindly to orchards, gardens, and the vicinity of farm buildings, and often live in villages and in the parks of large towns. Their diet is largely made up of insects that infest orchards and gardens. Their favorite foraging places are trees, where they may be seen examining every leaf in search of their customary food,



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BULLOCK ORIOLE

caterpillars and other leaf-haunting insects. When fruit trees are in bloom they are constantly busy among the blossoms, and probably save many of them from destruction.

For the investigation of the food of the Bullock oriole 162 stomachs were available. They were taken in the five months from April to August inclusive, and probably give a very fair idea of the food for those months. Analysis of the contents shows about 79 percent of animal matter to 21 of vegetable.

Animal food.—The animal food consisted mainly of insects, with a few spiders, a lizard, a mollusk shell, and eggshells. Beetles amounted to 35 percent, and all except a few ladybugs (Coccinellidæ) were harmful species. The coccinellids were found in 9 stomachs, but the percentage was insignificant. Many of the beetles were weevils, and quite a number belonged to the genus *Balaninus*, which lives upon acorns and other nuts. Ants were found in 19 stomachs, and 1 contained nothing else. Hymenoptera other than ants were found in 56 stomachs, and entirely filled 2 of them. Including the ants, they amount to nearly 15 percent of the food of the season. The month of maximum consumption was April, when they reached over 29 percent of the monthly food.

One of the most interesting articles of food in the oriole's dietary is the black olive scale (*Saissetia oleæ*). This was found in 45 stomachs, and amounted to 5 percent of the food. In one stomach these scales formed 87 percent of the contents; in another, 82; and in each of two others, 81 percent. In one of these 30 individual scales could be counted. Scales were evidently a standard article of diet. They were eaten regularly in every month of the oriole's stay except April. Hemiptera other than scales are eaten quite regularly. They amount to a little more than 5 percent of the food. The month of greatest consumption was July, when they formed over 13 percent. They were mostly stinkbugs, leafhoppers, and tree hoppers. Plant lice (Aphididæ) were found in one stomach.

Lepidoptera, in the shape of moths, pupæ, and caterpillars, are the largest item of the oriole's animal food. April, the month of the bird's arrival from the South, is the month of greatest consumption, nearly 63 percent. The month when the fewest are taken is July, not quite 8 percent. This also is the month when the Baltimore oriole eats the fewest caterpillars. For the Bullock oriole the average consumption during its summer stay is a little more than 41 percent against 34 percent by the Baltimore. Perhaps the most interesting point in connection with the Lepidoptera is the eating of the pupæ and larvæ of the codling moth (*Carpocapsa pomonella*). These were found in 23 stomachs, which shows that they are not an unusual article of diet. No less than 14 of the pupa cases were found in one stomach, and as they are very fragile, many others may have been present, but broken up beyond recognition. It is curious that the oriole should find these insects. During the greater part of their larval life they are concealed within the apple. When ready to pupate they crawl out and at once seek some place of concealment, such as a crevice in bark or among clods or rubbish, where they can undergo their changes. To find them, therefore, birds must hunt for them. This would be very natural work for woodpeckers, titmice, creepers, and nuthatches, but it seems a surprising habit for an oriole.

Grasshoppers probably do not come much in the oriole's way. They were eaten, however, to the extent of a little more than 3 percent. In June they rise to somewhat more than 11 percent, which is the maximum. August is the month in which most birds eat the greatest quantities of grasshoppers, but none of the orioles collected in that month had eaten any. In spite of the fact, however, that grasshoppers are eaten so sparingly, 2 stomachs, both taken in June, contained nothing else, and another had 97 percent of them.

Various insects and spiders, with a few other elements, make up the rest of the animal food, a little more than 5 percent. Spiders do not form any important percentage of the oriole's food, but are probably eaten whenever found. They were identified in 44 stomachs, but no great number appeared in any. The scales of a lizard were found in one stomach and the shell of a snail in another. Eggshells occurred in 8 stomachs, and one egg was apparently eaten when fresh.

Eggshells are often seen in birds' stomachs and in most cases are supposed to be empty shells, which have been thrown from the nest. In the examination of the stomachs of over 200 species of birds, eggshells have been found in some of the stomachs of a great majority of the species. While most of these may have been empty shells, some of the cases are very questionable, and it is probable that occasionally individuals of most species of birds yield to the temptation to eat a fresh egg when a favorable opportunity occurs.

Vegetable food.—Practically all of the vegetable food consists of fruit, which amounts to a little more than 9 percent. Other vegetable matter aggregating less than 2 percent is largely rubbish, probably taken accidentally. Fruit was eaten in the four months from May to August inclusive. The maximum quantity was taken in July, when it amounted to nearly 40 percent. It was found in 67 stomachs, of which 16 contained cherries; 11, figs; 5, blackberries or raspberries; 1, elderberries; and 34, fruit pulp not further identified. One stomach was entirely filled with the pulp and seeds of figs. While this is a high percentage of fruit, most of which is of cultivated varieties, it is probably well paid for by the destruction of harmful insects. It is doubtful if any fruit grower would be willing to sacrifice the oriole, with its brilliant plumage and cheerful song, even if it took more fruit than it now does.

SUMMARY.

From an esthetic point of view the Bullock oriole has few rivals, and from an economic standpoint it has only one fault—that it does eat some fruit. It is not, however, so abundant that its ravages are likely ever to become serious, and its present numbers should be strictly protected.

SPARROW FAMILY.

(*Fringillidæ.*)

The sparrow family embraces a large number of birds of wide distribution, great diversity of form, and considerable variation in food habits. They are in general characterized by short, stout, conical bills, with which they hull seeds or crush beetles and the toughest skinned fruit. They are the great seed eaters of the feathered race. The quantity of seeds of noxious weeds consumed by the host of sparrows, especially in winter, is enormous. While the great bulk of the food of this family consists of vegetable matter, most of the species eat some animal food during the period of reproduction, and feed their young upon it during the first two weeks of their lives. The sparrows proper, commonly known as finches, linnets, or buntings, are, with a few exceptions, of subdued colors and quiet habits and subsist mostly upon vegetable food. On the other hand, such aberrant forms as grosbeaks and towhees eat a certain amount of animal food throughout the year.

In California about 60 species and subspecies of sparrows proper have been recorded, besides about a dozen grosbeaks and towhees. Not all of these, however, have such habits as render them of economic importance, and as many of the subspecies do not differ essentially in their food they are treated together.

WILLOW GOLDFINCH.

(*Astragalinus tristis salicamans.*)

The willow goldfinch, while found over most of the State west of the Sierra, is very locally distributed. Its plumage is beautiful, and its song, while not remarkable for power or volume, is sweet and cheery. The western goldfinches, like the eastern, feed principally upon seeds, and seem to have a special taste for those of thistles. When one finds a ripe thistle head, he at once begins to pick out the seeds and scatter the down, at the same time making a great jubilation, as though he enjoyed the fun of seeing the down fly. This habit has earned for them the name of thistle bird. They are eminently seed lovers, and rarely eat anything else, except a few insects during the season of reproduction. The only mischief so far imputed to them is the eating of the seeds of useful plants, such as lettuce and other vegetables on seed farms. Investigation has failed, however, to find a case where the damage was considerable. The writer visited some of the largest seed farms in California and ascertained that while birds, especially goldfinches, ate some of the ripening seeds, the damage had never been serious enough to warrant any protective measures. The writer observed goldfinches feeding on lettuce seed, but the birds were few, and all they could eat would have no appreciable effect on the quantity of seed harvested.

One marked peculiarity of the goldfinches is their bibulous habits. They seem always in need of water, perhaps owing to the habit of eating dry seeds. The writer has seen more goldfinches drinking in one day than he has seen of all other species in his whole life.

Only 84 stomachs of the willow goldfinch were available for examination, but such is the uniformity of the food that a larger number would probably not give a very different result. No stomachs were taken in December, but all the other months were represented. The food for those months amounts to 5 percent of animal matter to 95 of vegetable. All the animal food was found in 10 stomachs, 9 being taken in March, April, and May, and 1, containing 2 larvæ, in September. Practically all the vegetable matter is seeds.

Animal food.—The animal food was composed entirely of 3 orders of insects: Bugs (Hemiptera), flies (Diptera), and caterpillars (Lepidoptera). Bugs were contained in 5 stomachs and were all plant lice (Aphididæ). They aggregated a little less than 2 percent. Flies were found in 1 stomach taken in April. They were in the shape of larvæ or maggots and amounted to less than one-half of 1 percent. Caterpillars were contained in 6 stomachs and aggregated less than 3 percent. Beetles, wasps, ants, and grasshoppers, which so often constitute the bulk of the animal food of birds, are entirely wanting in the stomachs of the willow goldfinch, as also are spiders.

Vegetable food.—Vegetable matter appeared in every one of the 84 stomachs, and 73 of them held no other food. Hulls of oats were found in 1 stomach taken in May. It amounted to 65 percent of the contents of that stomach, and was the only thing of economic value found in any one of the 84 stomachs. It amounted to less than one-half of 1 percent of the year's food. Seeds of various weeds come to over 91 percent of the diet, and are found in every stomach in every month. For seven months weed seed constituted the entire food. The following plants were identified: *Centaurea* or bur thistle in 18 stomachs, alfilaria or filaree in 13, sunflower in 12, groundsel in 4, mouse-ear, rust weed, and tarweed in 2 each. As the goldfinch takes a good deal of gravel into its stomach, many of the seeds are ground up so that recognition is impossible. A few stomachs contained a vegetable food that could not be identified, perhaps some large seed broken up and discolored. Two stomachs containing this substance were those of nestlings 12 days old. One was entirely filled with it, but the other contained 75 percent of caterpillars.

SUMMARY.

There are probably few birds that do so little harm as the willow goldfinch. Its animal food, though small in quantity, is composed entirely of harmful insects. It eats no fruit and practically no grain. Most of its food consists of the seeds of noxious or neutral plants. Its food habits commend the bird, as much as its bright plumage and fine song.

GREEN-BACKED GOLDFINCH.

(*Astragalinus psaltria hesperophilus.*)

The green-backed goldfinch (Pl. VI) occurs over most of California, except the mountains and the deserts, and is one of the most abundant birds. It is a lover of the orchard and garden, and delights to linger along the roads and in weed patches. Its favorite feeding grounds are in open pastures, where the bur thistle (*Centaurea melitensis*) grows, a plant specially adapted to the wants of the goldfinch, for it throws out from the roots short seed-bearing stalks that bear seed, while the rest of the plant is making growth and getting ready to produce the main crop. The goldfinches know where these seeds are, and apparently get every one of them. Next in favor is the groundsel (*Senecio*), which grows in orchards, and on the unripe seeds of which the goldfinches feed to repletion. In the investigation of the food of this bird 476 stomachs were examined. They were taken in every month, and are well distributed. Animal food amounts to 1.7 percent and vegetable food to 98.3.

Animal food.—Animal food was contained in 50 stomachs, all taken in the four months from June to September inclusive, except one, which was taken in November. This stomach contained 20 percent of some insect food, apparently flies. In one stomach taken in September beetles formed 1 percent of the contents. No other trace of a beetle was found. A small wasp or bee was identified in one stomach, also taken in September. It amounted to 2 percent of the contents and was the only hymenopterous insect found. Caterpillars amount to only a small fraction of 1 percent, and were contained in 2 stomachs, one taken in June and the other in July.

The great bulk of the animal food was made up of Hemiptera in the form of plant lice. These were found in 46 stomachs distributed through the four months from June to September inclusive, though more than half of them were taken in August. One stomach was entirely filled with these insects, and in another 300 were counted. Considered in relation to the food of the year, however, they amount to only 1.6 percent. Many of these plant lice are of the kind commonly called woolly aphids, because their bodies are covered with a white cottony appearing substance, really a white wax, which exudes from the body of the insect. While the destruction of this small number of insects may seem insignificant, yet the goldfinch is one of the forces that keep within reasonable bounds the immense swarms of these prolific and pestiferous creatures. By far the greater number of these aphids were found in the crops and not in the stomachs; but as many of the latter were not accompanied by the crops, possibly the goldfinch consumes many more of these insects than is shown above. Then, too, aphids are very fragile, and by the time they reached the stomach many of them were probably too much reduced to be identified.

Vegetable food.—The vegetable food may be divided into 4 categories: Fruit, grain, weeds, and miscellaneous matter. Fruit was found in 7 stomachs, all taken in June, July, and August. In one case it was a berry with small seeds, which have not yet been identified; in the others it could be classed only as fruit pulp. Altogether it amounts to three-tenths of 1 percent of the year's food. A single kernel of wheat was found in 1 stomach taken in December. Weed seed is the standard food of this goldfinch. It aggregates over 96 percent of the year's diet, and in January and March nothing else is eaten. The month of least consumption, August, shows over 86 percent, and in every other month it is above 94. While several species are eaten freely, the chief is the Napa, or bur thistle (*Centaurea melitensis*), which was found in 243 of the 476 stomachs, and would seem to be the staff of life of the goldfinch. It is a small hard seed covered with an apparently siliceous shell, with a hook at one end and a bunch of stiff bristles at the other.[a] Generally the bird skillfully removes this shell and swallows only the starchy pulp. Many kinds of weed seed were found in the 469 stomachs examined, and only 7 did not contain any; 394 contained nothing else.

Other vegetable food, some of it not satisfactorily identified and some of it rubbish, amounts to 1½ percent of the whole. In regard to eating seeds of garden vegetables on seed farms, what was said of the willow goldfinch will apply with equal truth to this species. What seemed to be the petals of flowers were found in a few stomachs, but did not reach a respectable percentage. It does not appear that the green-backed goldfinch requires any other food than weed seed, and of this one or two varieties suffice. The following is a list

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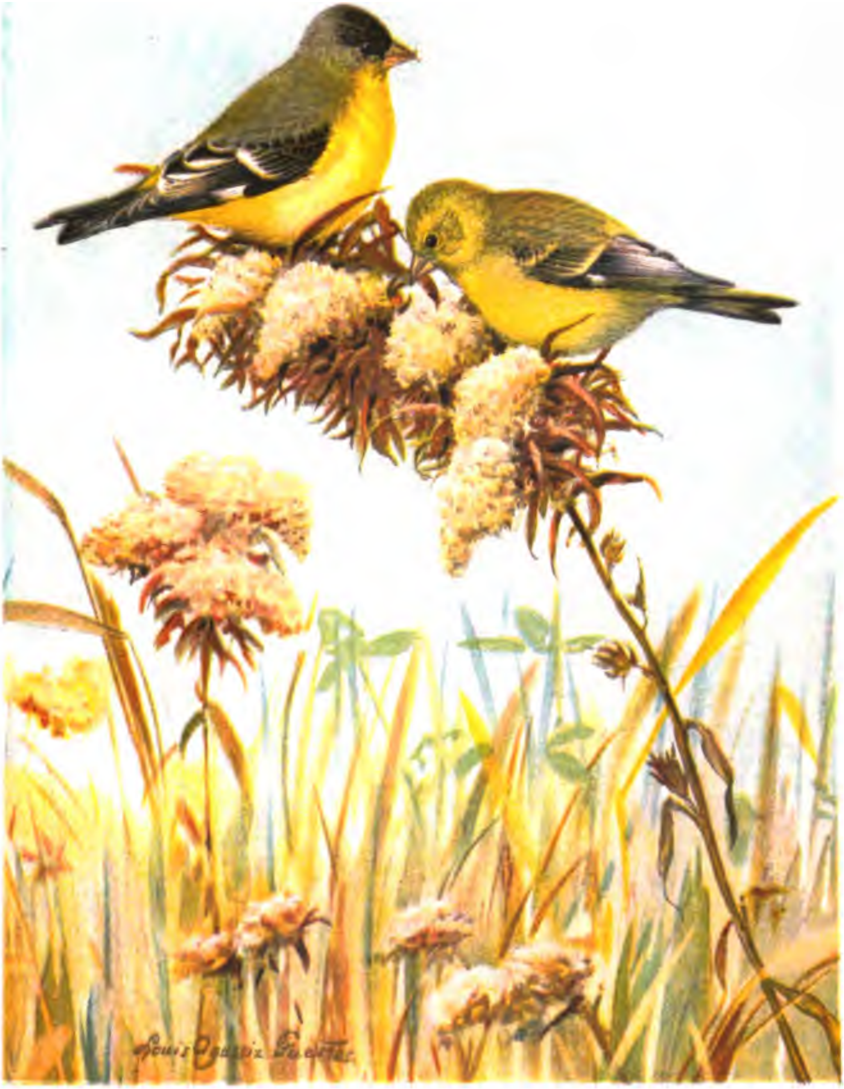
[a] Pl. II, fig. 1, Part I, opp. p. 16.



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GREEN-BACKED GOLDFINCH

of the seeds identified and the number of stomachs in which each species was found:

Sunflower (*Helianthus* sp.)	4
Lesser tarweed (*Hemizonia fasciculata*)	1
Tarweed (*Madia sativa*)	23
Mayweed (*Anthemis cotula*)	10
Groundsel (*Senecio vulgaris*)	33
Bur thistle (*Centaurea melitensis*)	243
Black nightshade (*Solanum nigrum*)	1
Turkey mullein (*Eremocarpus setigerus*)	18
Alfilaria (*Erodium cicutarium*)	9
Black mustard (*Brassica nigra*)	1
Miner's lettuce (*Montia perfoliata*)	2
Red maids (*Calandrinia menziesi*)	1
Pigweed (*Amaranthus retroflexus*)	30
Chickweed (*Stellaria media*)	3
Catchfly (*Silene* sp.)	1
Knotweed (*Polygonum* sp.)	2
Sorrel (*Rumex* sp.)	1
Sedge (*Carex* sp.)	6

SUMMARY.

If there are any faults in the food habits of the green-backed goldfinch, the writer does not know them. The little animal food it consumes consists of harmful insects, and practically all of its vegetable food consists of seeds of useless or harmful weeds. This goldfinch should be protected to the fullest extent.

INTERMEDIATE AND NUTTALL SPARROWS.

(*Zonotrichia leucophrys gambeli* and *nuttalli.*)

One or the other of these two subspecies of the white-crowned sparrow is found throughout the year in some part of California, and in winter the intermediate (*gambeli*) is distributed nearly all over the lower parts of the State. These sparrows frequent valleys, brushy hillsides, highways, and cultivated fields. The only complaint against them is that in spring and in winter they eat buds of fruit trees. Buds are usually overabundant, and the loss of some is generally a benefit to the tree; in any event it would require a very thorough disbudding to do much damage.

For the investigation of the bird's food, 516 stomachs were available, taken in every month of the year, though August was represented by only one, and May and July by two each. The first analysis gives 7.4 percent of animal matter to 92.6 of vegetable.

Animal food.—Beetles amount to 1.4 percent of the food. In June they reach nearly 8 percent, but in the other months are unimportant. Practically all of them are harmful. Hymenoptera amount to 1.9 percent. In June they reach over 16 percent, but in the other months rise barely above 1 percent. They were contained in 66 stomachs, of which 48 held ants and 18 contained wasps and bees. Parasitic species were noted in several stomachs.

Hemiptera amount to one-half of 1 percent, and were identified in 11 stomachs, of which 5 contained black olive scales; 2, leafhoppers; 3, stinkbugs; and 1, a tree hopper. Caterpillars are the largest item of animal food and amount to about 3.5 percent. Most of them were eaten in July, when they constituted 37.5 percent of the food, but as only 2 stomachs were collected in that month, this record can not be taken as final.

Vegetable food.—Fruit amounts to 4.5 percent. It was eaten rather irregularly, but most of it from March to July, inclusive. A mere trace was found in stomachs taken in September and October. Elderberries were found in 5 stomachs, blackberries or raspberries in 3, figs in 3, cherries in 2, and in 1 a small berry not positively identified. The cherries were unripe and only partly grown. A little pulp was noticed that might have been from some larger fruit. The great bulk of it was taken in May, June, and July. Grain aggregates 8.6 percent. It was contained in 69 stomachs, as follows: Oats in 56, wheat in 7, barley in 5, and corn in 1. Most of it was eaten in the three winter months, a little in the fall and spring, but practically none in summer. Only 3.5 percent was eaten in March, which would seem to indicate that this bird does not devour the newly sown grain.

Like many other fringilline birds, white-crowned sparrows subsist largely on weed seed. It is eaten freely in every month, and amounts to 74 percent of the yearly food. June is the month of least consumption, 33 percent, but that is the month when the most insects and fruit are eaten. The 1 stomach taken in August was entirely filled with this food, and it was over 90 percent of the contents of those taken in September and October. Of the 516 stomachs only 38, or a little more than 7 percent, contained no weed seed.

Following is a list of the species identified and the number of stomachs in which each was contained:

Sunflower (*Helianthus* sp.)	3
Lesser tarweed (*Hemizonia fasciculata*)	1
Tarweed (*Madia sativa*)	34
Mayweed (*Anthemis cotula*)	75
Bur thistle (*Centaurea melitensis*)	38
Sow thistle (*Sonchus asper*)	4
Prickly lettuce (*Lactuca scariola*)	1
Nightshade (*Solanum nigrum*)	70
Senna (*Cassia* sp.)	7
Lupine (*Lupinus* sp.)	1
Clover (*Trifolium* sp.)	1
Mountain lilac (*Ceanothus* sp.)	1
Poison oak (*Rhus diversiloba*)	12
Alfilaria (*Erodium cicutarium*)	45

Geranium (*Geranium dissectum*)	18
Black mustard ([illegible]*sica nigra*)	3
California poppy (*Eschscholtzia californica*)	1
Miner's lettuce (*Montia perfoliata*)	29
Red maids (*Calandrinia menziesi*)	4
Purslane (*Portulaca oleracea*)	4
Pigweed (*Chenopodium album*)	12
Rough pigweed (*Amaranthus retroflexus*)	208
Spurry (*Spergula arvensis*)	10
Chickweed (*Stellaria media*)	16
Catchfly (*Silene* sp.)	29
Knotweed (*Polygonum* sp.)	76
Sorrel (*Rumex* sp.)	18
Brome grass (*Bromus* sp.)	20
Wild oats (*Avena fatua*)	34
Canary seed (*Phalaris canariensis*)	2
Johnson grass (*Andropogon sorghum*)	1
Sedge (*Carex* sp.)	11
Unidentified	168

As this bird takes a great deal of gravel, the seeds eaten are soon ground into paste, which renders specific identification impossible. Many stomachs were entirely filled with food in this condition, which accounts for the large amount of unidentified material. Very few whole seeds were unidentified. The white-crown is evidently fond of variety, for several stomachs contained as many as 9 different species of seeds. It will be noted also that rough pigweed is the favorite food, while the Arkansas goldfinch preferred bur thistle.

Miscellaneous vegetable matter amounts to 5 per cent, and was found in 30 stomachs. Of these, 11 contained fragments of flowers, probably of fruit trees, for in some cases the embryo fruit could be made out. This is not a very heavy indictment on the score of destroying buds and blossoms. Fibrous vegetable matter of uncertain origin was found in quite a number of stomachs; perhaps it was grass which had been subjected to the grinding action of the stomach.

SUMMARY.

Evidently neither the farmer nor the fruit grower has much to fear from the white-crowned sparrow. On the contrary the bird destroys some insects, all of which are harmful, and a vast number of seeds of noxious weeds. The little fruit it eats is mostly wild, and its grain eating is practically confined to the months when the only grain available is waste or volunteer. In the above record there is little to substantiate the accusation that the bird destroys fruit buds, and probably it is only under very exceptional circumstances that it does any damage in this way.

GOLDEN-CROWNED SPARROW.

(*Zonotrichia coronata.*)

The golden-crowned sparrow arrives in California from the north in September, and departs for its summer residence in April. In winter it spreads over the country, lives wherever food can be obtained, except perhaps in the forest, and may often be seen in the garden among the fruit trees or in the rose bushes. It is also found in lonely canyons or on the cattle ranges in the hills. In general appearance and in food habits it does not differ essentially from the white-crown. For the determination of its food 184 stomachs were available, taken from October to April, inclusive. The animal food amounts to 0.9 percent, vegetable to 99.1.

Animal food.—The animal food consists of insects, and is pretty well distributed among the various orders. No great quantity was found in any one stomach, and it is eaten so rarely and in such small quantities that the wonder is that it is eaten at all. Singularly enough two worker honeybees were found in one stomach. It is evident that the golden-crown does not search for insects, and takes only those that come in its way.

Vegetable food.—The vegetable food consists of fruit, buds and flowers, grain, and some miscellaneous matter. Fruit can not be a prominent item in the food of this sparrow, owing to the time of year it spends in California. One stomach taken in March contained a little fruit pulp, probably left over from the previous season. Fruit was found also in 2 stomachs taken in October and in 2 taken in November. In one it consisted of elderberries; in one, of grape; in another, it was thought to be apple; while in the fourth, it was unidentifiable. In all, it amounts to a little more than 1 percent of the food. Remains of buds and flowers were found in stomachs taken in every month of the bird's stay in the State, except October and November, when buds are very small. They were found in 56 stomachs; the average for the season is 29.5 percent, and in March it rises to nearly 78 percent. Where this bird is abundant, it may do mischief if it visits the orchards. In the stomach of no other species yet examined has been found so much of this kind of food, which makes it probable that much of the bud and flower eating imputed to the linnet and white-crown is really done by the golden-crown.

Grain was eaten during every month of the bird's stay in the State, but as none of these was a harvest month, little damage was done. March, the sowing month, showed but little more than 5 percent, while over 66 percent was eaten in January. The average for the season was nearly 26 percent. It was found in 23 stomachs, of which 12 contained oats; 6, wheat; 2, barley; 2, corn; and 1, doubtful.

Weed seed amounts to 33 percent of the food and is eaten in every month. It is, however, complementary to the bud and blossom food, the one increasing as the other decreases. Weed seed begins with a percentage of 83 in October, and gradually diminishes, while buds and blossoms appear first in December with 22 percent and increase to their maximum in April.

Below is a list of species identified, showing the number of stomachs in which each was contained:

Tarweed (*Madia sativa*)	11
Mayweed (*Anthemis cotula*)	15
Bur thistle (*Centaurea melitensis*)	18
Nightshade (*Solanum nigrum*)	16
Lupine (*Lupinus* sp.)	1
Clover (*Trifolium* sp.)	2
Turkey mullein (*Eremocarpus setigerus*)	2
Poison oak (*Rhus diversiloba*)	30
Alfilaria (*Erodium cicutarium*)	16
Geranium (*Geranium dissectum*)	16
Mustard (*Brassica nigra*)	1
Rough pigweed (*Amaranthus retroflexus*)	18
Spurry (*Spergula arvensis*)	4
Chickweed (*Stellaria media*)	10
Catchfly (*Silene* sp.)	1
Knotweed (*Polygonum* sp.)	10
Sorrel (*Rumex* sp.)	10
Brome grass (*Bromus* sp.)	11
Sedge (*Carex* sp.)	1
Seeds of conifer	1
Unidentified	39

The last item includes stomachs in which the food was ground to a pulp, rendering identification impossible. Few whole seeds were unidentified. Poison-oak seeds are indicated as found in 30 stomachs, but as a matter of fact not a single seed of that plant was seen in any stomach. The birds ate only the wax which surrounds those seeds and which contains certain woody granules by which it can at once be identified. This species, then, does not aid in the dissemination of these noxious plants.

SUMMARY.

From the foregoing it is evident that the golden-crown during its stay in California does but little service in destroying insects. On the other hand, it does no direct harm to fruit, and little, if any, to grain. It does good by destroying weed seed, although not as much as some other species. By the destruction of buds and blossoms it may do serious harm where it is numerous and visits the orchards.

WESTERN CHIPPING SPARROW.

(*Spizella passerina arizonæ.*)

The western chipping sparrow occurs during the breeding season and early fall over most of the State, and winters sparingly in the southern part. Like its eastern relative it is very domestic, and often builds its nests in gardens and orchards. The bird well merits the name *socialis*, now, unhappily, superseded, and its gentle and confiding ways endear it to all bird lovers. It is one of the most insectivorous of all the sparrows, and is valuable in the garden or about the farm.

For the investigation of this bird's food 96 stomachs were available. They were taken from April to October inclusive, and probably give a fair idea of the food for that part of the year. It is quite likely that the winter food consists largely, if not entirely, of weed seeds, as 4 stomachs taken in the southern part of the State in winter (not included in this investigation) were almost entirely filled with this food. The first division of the stomachs' contents gives 45 percent of animal food and 55 percent of vegetable.

Animal food.—The animal food consists of insects and spiders, with a few bits of eggshell. Beetles were eaten from April to August inclusive, with the maximum of 23 percent in July. In one stomach were the remains of 30 weevils or snout beetles, but so badly crushed and broken that specific identification was impossible. The average monthly percentage is 6.7. Hymenoptera amount to 11.8 percent. They are represented mostly by ants, with which several stomachs were entirely filled. The greatest quantity were eaten in June, when they aggregated 67.5 percent, or more than four-fifths of the animal food for the month. In the other months they were taken rather irregularly and in small quantities.

Hemiptera are eaten to the average extent of 7.5 percent. They appear rather irregularly, and the greatest consumption is in October, 20 percent. None were found in August or September stomachs, but as only 4 were collected in October, and not many in the two previous months, the record can not be considered as fully reliable. They consist of stinkbugs and leafhoppers, with a few others, of which the most interesting are scales and plant lice. These were each found in 5 stomachs. The scales were the black olive species (*Saissetia oleæ*). Diptera, or flies, do not appear to be favorite food with the chipping sparrow. They were eaten only in the months from April to July inclusive, with the maximum consumption in May, when about 12 percent were taken, or more than half of all. The average per month is only 3 percent.

Caterpillars are evidently the favorite animal food, as they were eaten to an average extent of 14.7 percent, or more than any other insect. They appear in the food during every month of the bird's stay in the north except October, and probably a greater number of stomachs would have shown some in that month. Two stomachs contained pupæ of the codling moth. Only one stomach held grasshoppers, and that was taken in June. Some spiders and eggshells make up nearly 1 percent, and complete the animal food.

Vegetable food.—Grain in the shape of oats was found in 5 stomachs, all collected in July. The total amount for that month is 6 percent, or less than 1 percent for the season. A mere trace of fruit was found in one stomach in June. Weed seed was eaten in every month of the bird's stay, and probably throughout the year. It amounts to over 53 percent of the food, and in September rises to 98 percent. June was the month of least consumption, 9 percent, when insects evidently took its place. The species identified, and the number of stomachs in which each was found, are as follows:

Bur thistle (*Centaurea melitensis*)	2
Nightshade (*Solanum nigrum*)	1
Alfilaria (*Erodium cicutarium*)	37
Miner's lettuce (*Montia perfoliata*)	3
Red maids (*Calindrinia menzeisi*)	2
Rough pigweed (*Amaranthus retroflexus*)	16
Chickweed (*Stellaria media*)	13
Knotweed (*Polygonum* sp.)	1
Timothy (*Phleum pratense*)	1
Meadow grass (*Poa* sp.)	1
Panic grass (*Panicum sanguinale*)	2
Wild oats (*Avena fatua*)	1
Sedge (*Carex* sp.)	2
Unidentified	32

Most of the unidentified seeds were so badly ground up that it was impossible to recognize the species. The greater part probably belonged to species included in the above list. A few very small grass seeds were not further identified.

Feeding the young.—A nest with 4 young of this species, about 6 days old when first observed, was watched at different hours on four days. On the morning of the fifth day a pair of jays carried off the young birds. In the seven hours of observation 119 feedings were noted, or an average of 17 feedings per hour, or four and one-fourth feedings per hour to each nestling. This would give for a day of fourteen hours at least 238 insects destroyed by the brood.

SUMMARY.

In the foregoing discussion of the food of the chipping sparrow it plainly appears that the diet is made up almost exclusively of harmful elements. No useful beetles of any consequence were eaten. Of Hymenoptera, ants, which are either harmful or neutral, predominate, while caterpillars, which are a universal pest, are the favorite animal food. In the vegetable portion of the diet fruit and grain appear as mere traces, while the seeds of noxious weeds make up the bulk of the food. It is not necessary to further eulogize this bird, as it is already welcomed everywhere, as it should be.

WESTERN SNOWBIRD.

(*Junco hyemalis thurberi* and other subspecies.)

Several subspecies of junco occur in California. One form, *J. pinosus*, is a resident of the Monterey Bay region the year round. Another, *thurberi*, is a resident of the State throughout the year, but winters in the valleys and breeds in the mountains. Two others, *oreganus* and *connectens*, occur in winter only, when all the forms spread out and cover a considerable part of the State. It would be better to treat the four races separately, but as many of the stomachs were collected before the races were recognized, their exact identity is unknown. They will be discussed, therefore, as a whole, but what is said of summer food will not apply to *oreganus* and *connectens*.

For this investigation 269 stomachs were available. They were collected in every month except May. March, April, June, and August are poorly represented, but the other months have each a good quota. The first analysis of the food gives 24 percent of animal matter to 76 of vegetable.

Animal food.—Beetles amount to 5 percent, and nearly all were eaten in the months from March to July inclusive, with no record for May. With the exception of two ladybirds (Coccinellidæ) found in 2 stomachs, not a useful species was identified in the whole. Weevils make up the bulk of this item, and a species of scolytid (*Phlœosinus punctatus*) was found in 1 stomach to the extent of 65 percent of its contents. Hymenoptera were represented mostly by ants, with a few wasps, amounting in all to a little more than 2 percent of the food. Caterpillars are apparently the favorite insect food, forming 9.4 percent of the diet. The great bulk were eaten from April to August, and the single stomach taken in August contained 67 percent of them. No special pest was identified. Bugs, grasshoppers, a few other insects, and spiders, make up the remainder of the animal food, 7.3 percent.

Vegetable food.—Seeds of blackberry or raspberry were found in 1 stomach and elderberries in 2. In 14 stomachs taken in November was found fruit pulp averaging over 11 percent of the food of the month. As all fruit except olives is harvested before that time, probably the berries were of no value.

Grain was eaten from October to March inclusive, and amounted to 8 percent for the year. All of it was contained in 30 stomachs, as follows: Oats in 15, wheat in 9, barley in 4, corn in 1, and unidentified in 1. None was taken in a harvest month. The greatest amount, more than 30 percent, was eaten in March, the sowing month, probably much of it from newly sown fields.

Weed seed aggregates 61.8 percent of the food, and was eaten in every month. In September it amounted to nearly 95 percent. A few seeds, mostly of grass, were not identified. The following is a list of identified species and the number of stomachs in which each was contained:

Ragweed (*Ambrosia* sp.)	1
Tarweed (*Madia sativa*)	4
Mayweed (*Anthemis cotula*)	11
Bur thistle (*Centaurea melitensis*)	16
Sow thistle (*Sonchus asper*)	2
Nightshade (*Solanum nigrum*)	11
Lupine (*Lupinus* sp.)	1
Clover (*Trifolium* sp.)	1
Poison oak (*Rhus diversiloba*)	13
Alfilaria (*Erodium cicutarium*)	34
Geranium (*Geranium dissectum*)	4
Mustard (*Brassica nigra*)	3
Miner's lettuce (*Montia perfoliata*)	13
Red maids (*Calandrinia menziesi*)	2
Purslane (*Portulaca oleracea*)	1
Rough pigweed (*Amaranthus retroflexus*)	35
Spurry (*Spergula arvensis*)	9
Chickweed (*Stellaria media*)	42
Catchfly (*Silene* sp.)	21
Knotweed (*Polygonum* sp.)	33
Sorrel (*Rumex* sp.)	26
Wild oats (*Avena fatua*)	8
Timothy (*Phleum pratense*)	1
Panic grass (*Panicum* sp.)	3
Sedge (*Carex* sp.)	14
Coniferous seeds not identified	4
Unidentified	2

Remains of blossoms were found in 1 stomach. The seeds of poison oak were not discovered in the stomachs, but the characteristic granules that are embedded in the waxy coating of the seeds were identified, thus showing that the birds eat this wax without swallowing the seed itself.

SUMMARY.

The insect food of the snowbirds is composed almost entirely of harmful species, of which caterpillars form the largest item. Snowbirds do no damage to fruit or grain. They eat large quantities of weed seeds, thereby rendering a service to agriculture.

WESTERN SONG SPARROW.

(*Melospiza melodia samuelis*, *heermani*, and other subspecies.)

Song sparrows inhabit not only the greater part of California but all of the United States, except areas where conditions are unsuitable. These birds vary much in habits, as well as in size and coloration. Some forms live along streams bordered by deserts, others in swamps among bulrushes and tules, others in timbered regions, others on rocky barren hillsides, and still others in rich fertile valleys. Each area has its peculiar form, and in fact it is hard to imagine any locality adapted to a land bird of the Temperate Zone which does not fit some form of the song sparrow. With such a variety of habitat, the food of the species necessarily varies considerably. It is impossible to treat here the several forms separately, and the best we can do is to give a general idea of the yearly diet of the species as a whole.

For the investigation of the food of the western song sparrows, 321 stomachs, belonging to 4 or 5 subspecies, were available. They were collected in every month of the year, and fairly represent the whole State. The first analysis separates the food into 21 percent of animal matter and 79 of vegetable. This is less animal food than is eaten by the snowbird, much less than by the chipping sparrow, but much more than by the white-crowned or golden-crowned sparrows.

Animal food.—Animal food, consisting principally of insects, is eaten with a fair degree of regularity through the year. Beginning with a minimum of 3 percent in September, based on the examination of 97 stomachs, it rises gradually to a maximum of over 71 percent in May. Beetles are the largest item, and a greater or less number were eaten every month except December, an omission probably accidental. The average for the year is 6.6 percent. In June, the month of greatest consumption, nearly 29 percent were eaten. With the exception of the remains of tiger beetles (Cicindelidæ) in 3 stomachs and predaceous ground beetles (Carabidæ) in 10, all were of harmful families, the leaf beetles (Chrysomelidæ) and weevils (Rhynchophora) being most prominent.

Hymenoptera (bees, wasps, and ants) were taken very irregularly, and amount to only 3 percent of the food. Ants were found in 22 stomachs, and bees and wasps in 20. Hemiptera, or bugs, form only about 2 percent of the year's food, but 17 percent of the food eaten in May. The black olive scale was found in 2 stomachs and a species not identified in 1. Leafhoppers, spittle insects (Cercopidæ), and a few other forms make up the rest of this item. Diptera (flies) were eaten from May to September inclusive. In May they amount to over 11 per cent, but fall away rapidly, and the aggregate for the year is only 2 percent. A few crane flies (Tipulidæ) and the house fly family (Muscidæ) were the only forms recognized.

Caterpillars, while taken in nearly every month, were eaten very irregularly and to the extent of 4.3 percent only. There was a fair percentage from March to August inclusive, but in other months a trifle or none, except December, in which 5 percent were found. May shows the greatest amount, 14 percent. Grasshoppers are apparently not relished by the song sparrow. A mere trace of these insects was found in a few stomachs collected in February, May, June, and August. They do not form an appreciable percentage of the food. A few insects too finely pulverized for recognition, some spiders, and a few snails make up the remainder of the animal food, 2.5 percent.

Vegetable food.—Evidence of fruit eating was found in 19 stomachs as follows: Seeds of Rubus (blackberries or raspberries) in 9, elderberries in 4, cherries in 2, figs in 1, and fruit pulp or skins in 3. In all it amounts to a trifle more than 2 percent of the food. Grain was absent in all stomachs collected from February to June inclusive, and in November. What was eaten in the other months comes to a little more than 3 percent for the year. The most, 11 percent, was taken in January, but July shows very nearly the same. This last was perhaps gleaned from the field. The varieties are as follows: Barley found in 7 stomachs, oats in 5, and wheat in 2.

The chief food of the song sparrow is weed seed. This amounts to 73 percent of the year's food, and varies from one-fifth to very nearly the whole of each month's diet. In September, when animal food is at its minimum, weed seed reaches a little more than 93 percent. On the other hand, in May, when animal food is at its maximum, weed seed shrinks to a little less than 21 percent. Of the 321 stomachs, 302, or 94 percent, contained weed seed. Of these, 171, or 53 percent of all, were completely filled with it. There were only 19 stomachs that did not contain more or less of this food. The record of this sparrow for eating weed seed is excelled by only four species of California birds—the linnet, the two goldfinches, and the white-crowned sparrow.

Following are the species of weed seeds identified and the number of stomachs in which each was found:

Sunflower (*Helianthus* sp.)	1
Lesser tarweed (*Hemizonia fasciculata*)	1
Tarweed (*Madia sativa*)	9
Mayweed (*Anthemis cotula*)	7
Bur thistle (*Centaurea melitensis*)	36
Sow thistle (*Sonchus asper* and *oleraceus*)	5
Salsify (*Tragopogon porrifolius*)	1
Henbit (*Lamium amplexicaule*)	1
Nightshade (*Solanum nigrum*)	35
Nine bark (*Opulaster opulifolius*)	1
Turkey mullein (*Eremocarpus setigerus*)	1
Poison oak (*Rhus diversiloba*)	3
Alfilaria (*Erodium cicutarium*)	23

Geranium (*Geranium carolinianum*)	1
Mustard (*Brassica nigra*)	1
Miner's lettuce (*Montia perfoliata*)	26
Red maids (*Calandrinia menziesi*)	6
Pigweed (*Chenopodium album*)	1
Rough pigweed (*Amaranthus retroflexus*)	113
Spurry (*Spergula arvensis*)	12
Chickweed (*Stellaria media*)	32
Catchfly (*Silene* sp.)	3
Knotweed (*Polygonum* sp.)	44
Sorrel (*Rumex* sp.)	16
Brome grass (*Bromus* sp.)	4
Wild oats (*Avena fatua*)	14
Timothy (*Phleum pratense*)	1
Canary seed (*Phalaris caroliniana*)	2
Fox tail (*Chaetochloa* sp.)	1
Panic grass (*Panicum sanguinale*)	4
Sedge (*Carex* sp.)	8
Unidentified	97

As usual, the unidentified were either ground to pulp or were seeds of some unknown grass. Evidently the rough pigweed seed (*Amaranthus*) is the favorite. Several stomachs contained nothing else.

SUMMARY.

The economic status of the song sparrow can be summarized in a few words. It eats a comparatively small number of insects, the majority of which are noxious. Fruit and grain are eaten so little as to be of no consequence. Nearly three-fourths of the diet consists of seeds of weeds, most of which are a nuisance. Neither stomach examinations nor field observations furnish evidence that the song sparrow does any harm.

SPOTTED TOWHEE.

(*Pipilo maculatus* and subspecies.)

Under one or other of its several subspecific forms the spotted towhee occurs almost throughout California. As it is resident over much of its range, the good or harm it does continues through the year. It is eminently a bird of the ground and underbrush, and delights in the thickest shrubbery, where it scratches among the dead leaves and twigs. Anyone who approaches the bushes too closely will probably see the bird depart from the opposite side and plunge into another thicket, and in this way one may chase it for hours with no more than an occasional glimpse. This bird is not common about orchard or garden, the chaparral-covered hillsides and canyons being more congenial resorts. It is abundant and widely distributed, and hence is comparatively important from an economic point of view.

For the investigation of the food of this bird 139 stomachs were at hand, collected in every month of the year, though November to May inclusive were not represented as fully as was desirable. The first analysis of the food gives 24 percent of animal matter to 76 of vegetable. Dead leaves, bits of twigs, rotten wood, and other rubbish are very common in the stomachs, and probably are swallowed accidentally with more nutritious morsels.

Animal food.—Beetles are the largest item of animal food, and amount to a little more than 10 percent. Although the larger part of the towhee's living is gleaned from the ground, only 4 stomachs contained the remains of predaceous ground beetles, and 2 others the remains of ladybirds (Coccinellidæ). Weevils were found in 26 stomachs, and in 13 stomachs were the remains of that harmful chrysomalid beetle *Diabrotica soror*. Besides these were fragments of elaterids, buprestids, and cerambycids, all of which in the larval state bore into trees and other plants and do great mischief. Hymenoptera amount to 6 percent of the diet, but are eaten rather irregularly. They are mostly taken in summer, but some appear at all times of the year. They were found in 39 stomachs, of which 25 contained ants, and 14, wasps and bees.

Bugs (Hemiptera) amount to 14 percent, and are distributed among several families; but the only point that merits mention is that the black olive scale was found in 4 stomachs and an unidentified scale in 1. The spotted towhee does not appear to care for grasshoppers. They form only 1.7 percent of the year's food, and are eaten very irregularly. In June they reach a little more than 11 percent, in August they amount to only 6 percent, and few were found in other months. Caterpillars aggregate 3.5 percent of the food. They are eaten rather irregularly, without much regard to season, but the greatest number, 12 percent, were taken in April. A few flies, some other insects, spiders, millepeds, and sowbugs (*Oniscus*) make up about 3 percent, the remainder of the animal food. These last are just what the bird would be expected to get by scratching among underbrush.

Vegetable food.—Fruit was eaten in every month from May to November inclusive, with a good percentage in each month. January also shows 11.7 percent, but this was either wild or waste. The average for the year is 17.7 percent. The month of greatest consumption was November, when it amounted to 53.6 percent. All of it was in the shape of fruit pulp, not further identifiable. At that time of year it could have been of no value. Fruit pulp, identified only as such, was found in 23 stomachs. Rubus seeds and pulp (raspberries or blackberries) were found in 23 stomachs; cherries, grapes, and figs in 1 each. Elderberries (*Sambucus glauca*) were found in 6 stomachs, snowberries (*Symphoricarpos racemosus*) in 3, and black twinberries (*Lonicera involucrata*) in 1. The fruit eaten in June and July was almost entirely Rubus fruit, which may have been either wild or cultivated, except in one case, where the seeds of Logan berries were identified. In August and September the fruit eaten was of the larger varieties, like apricots, peaches, and prunes. Later in the year the wild kinds only were taken. The one stomach which contained cherries was collected the last of May. If this bird were as abundant as the linnet, it would do considerable damage to the larger fruits. Under present conditions its depredations probably pass unnoticed.

Grain was eaten from June to December, inclusive, except in November. The amount for the year is 4.7 percent. In August, the month of greatest consumption, 16 percent was taken. It was found in 17 stomachs, of which 10 contained oats; 3, wheat; 3, corn; and 1, barley. As most of this was gleaned after harvest, probably no harm was done.

Weed seed is a standard article of diet with this bird, as with many others. It was found in 93 of the 139 stomachs, and 11 contained nothing else. The average amount for the year is 34.6 percent of the food, and it was found in every month except March; but as only one bird was collected in that month, the exception is probably accidental. January was the month when most was eaten, 62.8 percent, but as some other months stood nearly as high, this has no special significance. Bur thistle seems to be the favorite seed, although the towhee does not show so strong a preference for any weed as some other species exhibit.

Following is a list of species identified and the number of stomachs in which each was found:

Tarweed (*Madia sativa*)	10
Bur thistle (*Centaurea melitensis*)	27
Nightshade (*Solanum nigrum*)	8
Plantain (*Plantago lanceolata*)	1
Senna (*Cassia* sp.)	1
Clover (*Trifolium* sp.)	1
Legumes unidentified	3
Turkey mullein (*Eremocarpos setigerus*)	2
Poison oak (*Rhus diversiloba*)	11
Sumac (*Rhus* sp.)	1
Alfilaria (*Erodium cicutarium*)	11
Mustard (*Brassica nigra*)	1
Miners' lettuce (*Montia perfoliata*)	8
Red maids (*Calandrinia menziesi*)	2
Rough pigweed (*Amaranthus retroflexus*)	11
Chickweed (*Stellaria media*)	8
Knotweed (*Polygonum* sp.)	4
Sorrel (*Rumex* sp.)	5
Wild oats (*Avena fatua*)	9
Sedge (*Carex* sp.)	3
Unidentified	34

Another article of the towhee's food is mast. It is somewhat difficult to distinguish between mast and weed seed when both are ground to a pulp. As divided, however, mast amounts to 15.6 percent of the food. It was found in moderate quantities in stomachs collected from September to February inclusive, and in April also it reached 25 percent, with a trace in June. February was the month in which most was eaten, 46.5 percent. It was found in only 22 stomachs, but 8 of them were completely filled with it. Leaf galls and some unidentified vegetable matter make up a little more than 3 percent, and complete the vegetable food.

SUMMARY.

The spotted towhee is not numerous enough to inflict any great damage, whatever its food habits. Should it become very abundant it might do harm to fruit; but it is so shy that the more the country is cleared and settled the more rare is it likely to become.

CALIFORNIA TOWHEE.

(*Pipilo crissalis* and *senicula*.)

In rural communities on the Pacific coast, the California towhee occupies a place similar to that of the robin in the east. It is quite domestic in habits, and not only is it a familiar sight about orchards and gardens, but it often builds its nest in the shrubbery and vines around the house. Its habits are somewhat more terrestrial than those of the robin, and the fruit it eats is largely that which it finds on the ground. Like the spotted towhee, it forages much under bushes and vines, scratching among the rubbish for food; however, it does not confine itself to such places, but frequents also the open ground, looking for insects and seeds. At such times a pair are almost invariably seen together. The species does not migrate. One or other of its subspecies inhabits most of the valley and foothill country of California west of the Sierra Nevada and San Jacinto mountains.

For the study of the bird's food 399 stomachs were available, collected in every month, with a fair number in each month. The first analysis gives 14.26 percent of animal food to 85.74 of vegetable. The animal food consists of insects and a few spiders, millepeds, and snails. The vegetable part is made up of fruit, grain, weed seeds, and a few miscellaneous substances.

Animal food.—The largest item of the animal food consists of beetles, which amount to 5 percent. The predaceous ground beetles (Carabidæ) were found in 30 stomachs, and were the only useful beetles eaten. Weevils, or snout beetles, were found in 55 stomachs, of which 1 contained 15. Among them was identified one specimen of *Calandra oryza,* the rice weevil, an insect that does much harm to rice. A decidedly harmful species of chrysomelid beetle (*Diabrotica soror*) was found in 43 stomachs. All the other beetles, which belong to several families, are harmful. While beetles were eaten in every month except December, the great bulk were taken from April to July, inclusive. In June they amount to nearly 15 percent, which is the highest for any month.

Hymenoptera amount to less than 2 percent. They consist of ants found in 47 stomachs and bees or wasps in 23 stomachs. Hemiptera, or bugs, are eaten to a small extent in nearly every month, but do not reach a high percentage in any. The maximum, 6 percent, occurs in March. The average is barely 1 percent for the year. The favorite kinds appear to be leafhoppers, shield bugs, and stinkbugs. Black olive scales were found in 11 stomachs, and a second species, not identified, in 1.

Caterpillars are eaten sparingly in every month. The amount for the year is 3.26 percent, and the maximum consumption, 8.5 percent, occurs in March. Pupæ of the codling moth were found in 2 stomachs. Grasshoppers and crickets amount to 2.5 percent for the year. In July they aggregate nearly 16 percent, which is a remarkably small amount for such a confirmed ground feeder as the towhee. They are eaten rather irregularly from April to October inclusive, with a trace in January. The remainder of the animal food, consisting of a few flies and other insects, spiders, millipeds, and snails, amounts to a little more than one-half of 1 percent.

The following insects were identified in the stomachs:

COLEOPTERA.

Bradycellus rupestris.
Philonthus albionicus.
Tachyporus californicus.
Hypnoides ornatus.
Ptilinus ruficornis.
Aphodius rugifrons.
Aphodius rubidus.
Diabrotica soror.
Blapstinus pulverulentus.
Blapstinus rufipes.
Notoxus alamedæ.
Calandra oryza.

HEMIPTERA.

Saissetia oleæ.

LEPIDOPTERA.

Carpocapsa pomonella.

Vegetable food.—Fruit was eaten in every month from April to October inclusive, and also in December and January. The total for the year is 4.4 percent of the food. The greatest quantity was taken in June, when it amounted to 9.3 percent. Fruit, consisting of pulp and skins without seeds, was contained in 24 stomachs, Rubus fruits (blackberries or raspberries) in 28, cherries in 4, strawberries in 3, and elderberries in 41. Thus the towhee does no great damage to fruit—in fact, the fruit eaten is mostly wild or that which has been injured and left on the ground.

Grain is eaten regularly in every month and in a fair quantity. It amounts for the year to about 28 percent. The most is taken in fall and winter, though the variation is not very marked. August appears to be the month of greatest consumption, but it is doubtful if this would hold true if more stomachs were examined, as October is about the same. June shows a higher percentage than either May or July, which indicates that some of the grain was gathered from the harvest field. Oats were the favorite kind, found in 140 stomachs. Barley was contained in 34, wheat in 16, and corn in 6. Sixteen stomachs were filled with grain alone, most of them with oats, but several with barley and one with corn.

The towhee is another of those species whose standard food is weed seed. It amounts to nearly 51 percent of the yearly diet. Even in June, the month of least consumption, it amounts to one-fifth of the food, while in December it reaches its maximum, 83.6 percent; but a good percentage is eaten in every month, no matter what other food is at hand.

Weed seed was found in 304 stomachs, and 46 contained nothing else. The quantity of this seed consumed by the towhees of California in one year must be enormous. The following are the species identified and the number of stomachs in which each was found:

Sunflower (*Helianthus* sp.)	1
Lesser tarweed (*Hemizonia fasciculata*)	7
Tarweed (*Madia sativa*)	34
Mayweed (*Anthemis cotula*)	6
Milk thistle (*Silybum marianum*)	1
Bur thistle (*Centaurea melitensis*)	39
Burweed (*Amsinckia tesselata*)	4
Nightshade (*Solanum nigrum*)	22
Plantain (*Plantago lanceolata*)	1
Lupine (*Lupinus* sp.)	19
Clover (*Trifolium* sp.)	9
Legumes not further identified	39
Turkey mullein (*Eremocarpos setigerus*)	5
Poison oak (*Rhus diversiloba*)	7
Alfilaria (*Erodium cicutarium*)	55
Geranium (*Geranium dissectum*)	1
Yellow sorrel (*Oxalis corniculata*)	4
Mustard (*Brassica nigra*)	10
Poppy (*Eschscholtzia californica*)	2
Miners' lettuce (*Montia perfoliata*)	26
Red maids (*Calandrinia menziesi*)	4
Pigweed (*Chenopodium album*)	1
Rough pigweed (*Amaranthus retroflexus*)	77
Spurry (*Spergula arvensis*)	2
Chickweed (*Stellaria media*)	27
Catchfly (*Silene* sp.)	5
Knotweed (*Polygonum* sp.)	40
Sorrel (*Rumex acetosella*)	10
Brome grass (*Bromus* sp.)	5
Wild oats (*Avena fatua*)	33
Canary seed (*Phalaris canariensis*)	1
Panic grass (*Panicum* sp.)	1
Unidentified	77

Mast, in the shape of acorn meat, was taken to a slight extent. It reaches about one-half of 1 percent for the year. Vegetable rubbish aggregates 2.4 percent.

Food of young.—Among the 399 stomachs already discussed were those of 16 nestlings. They consisted of one brood of 3 about 2 days old; 3 broods, 9 in all, about 10 days old; and one brood of 4, probably 2 weeks old. The three youngest ones had been fed entirely on animal food, mostly grasshoppers, caterpillars, and spiders, with a few bugs. The 9 next in age had been fed animal matter to an average extent of 92 percent, to 8 percent of vegetable food. The animal food differs in proportions, not in constituents, from that taken by the adults. It is composed mainly of grasshoppers and caterpillars, with a few beetles, bugs, and wasps. The vegetable matter contains a little fruit, but the greater part is made up of wads or tangles of vegetable fibers. In one stomach the tangle consisted of horsehair. The same fact has been noted with the young of other species. The four that were 2 weeks old had been fed 95 percent of animal food and 5 percent of vegetable matter. The animal part is not so largely composed of grasshoppers, caterpillars, and spiders as with the younger birds, but beetles, wasps, and ants are more prominent. All of them contained remains of the beetle *Diabrotica soror* to an average extent of nearly 33 percent. Every one of these 4 stomachs contained a tangle of vegetable fibers, which constituted the whole of the vegetable food except one seed.

Some observations were made upon the feeding of nestlings of this species. It was found that the young are not fed as often as those of some other species, but probably get more at each feeding. The parent visiting the nest to feed the young gives food to all of them before leaving, and evidently regurgitates it from the gullet for this purpose. As the result of watching two nests for several hours, the maximum number of feedings in one hour was found to be 6, but from 2 to 4 was nearer the average. During the intervals between the feedings the parents could be seen hopping about on the ground and in the shrubbery searching for food, with which they appeared to gorge themselves, for caterpillars and other insects could be seen projecting from their bills. Both parents took part in the feeding, though when the nestlings were very young one bird stayed near or upon the nest until the other came, when they exchanged work.

SUMMARY.

The little animal food the California towhee eats is mostly of an injurious character. While eminently a ground feeder, it does not eat more of the predaceous ground beetles (Carabidæ) than other birds less terrestrial in their habits, and no more than a due proportion. In its vegetable food it probably does little, if any, damage. The amount of fruit eaten is small, and is mostly either damaged or wild. While it eats considerable grain, the great bulk is taken in the fall and winter months. Probably it does not visit the harvest fields much, for although a ground frequenter, it likes the presence of trees and bushes. The service it performs in destroying the seeds of weeds should be sufficient to cover a number of sins, but fortunately there are none serious enough for consideration.

BLACK-HEADED GROSBEAK.

(*Zamelodia melanocephala.*)

During the six months from April to September inclusive, the black-headed grosbeak occurs throughout the State of California, excepting the arid deserts and boreal mountain summits. Like its eastern relative, the rose-breasted grosbeak, it takes readily to orchards and gardens, and is common in agricultural districts. It is a bird of beautiful plumage and sweet song, and is a welcome addition to the attractions of rural life. It often nests in orchard trees, and, as is perfectly natural, gets much of its food there. While this consists mainly of harmful insects, a goodly part of it is fruit. The grosbeak, as its name indicates, has a very powerful bill, and has no difficulty in cutting the skin of the firmest fruit. It feeds upon cherries, apricots, and similar fruits to a considerable extent, but on the other hand it habitually consumes some of the worst insect pests, such as the black olive scale, the 12-spotted diabrotica, and the codling moth. The destruction of this trio alone should entitle the bird to great consideration, but it eats also other destructive insects.

For the laboratory investigation of this bird's food 225 stomachs were accessible. They were collected in the six months from April to September inclusive, a fair number in each, except the last, when only 3 were obtained. These stomachs contained about 57 percent of animal matter to 43 of vegetable. The animal matter is composed of insects and spiders, with a few traces of vertebrates. Insects, such as beetles, scales, and caterpillars, constituted nearly 53 of the 57 percent of animal food.

Animal food.—Of the animal food, beetles are the largest item. They were found in 190 of the 225 stomachs. Of these, predatory ground beetles (Carabidæ) were found in 16 stomachs, and ladybird beetles (Coccinellidæ) in 2. To offset the destruction of these useful insects, the 12-spotted diabrotica, which often does serious injury to fruit trees, was found in 109 stomachs. Many weevils were found, and great numbers of several species of leaf beetles (Chrysomelidæ). To this family belongs the notorious Colorado potato beetle, which at one time seemed likely to ruin the potato industry of the East. The bird which attacked this pest constantly and systematically was the rose-breasted grosbeak, a near relative of the one under consideration. When the potato beetle finds its way into California, as eventually it undoubtedly will, the black-headed grosbeak is the bird most likely to become its active enemy.

Hymenoptera in the form of bees and wasps with a few ants aggregate less than 2 percent. A worker honeybee was found in one stomach. Scale insects amount to 19.83 percent, or practically one-fifth of the whole food. Most of these were the black olive scale (*Saissetia oleæ*), but a few were the plum and prune scales (*Lecanium corni* and *L. pruinosum*). So persistently are scales eaten by this bird that they were found in 142 of the 225 stomachs, or 63 percent of all. While they did not entirely fill any stomach, in 26 they equaled or exceeded 50 percent of the contents. Hemiptera other than scales amount to a trifle over 1 percent.

Caterpillars, pupæ, and a few moths aggregate 7.7 percent. They were mostly eaten in April and May. Pupæ or larvæ of the codling moth were found in 26 stomachs, one stomach containing the remains of 29. Flies, grasshoppers, a few other insects, spiders, and miscellaneous creatures make up somewhat more than 1 percent. Eggshells were found in several stomachs and the bones of a small fish in one. The animal food of the grosbeak, it will be observed, is nearly all included in the 3 items, beetles, scales, and caterpillars. The other substances appear to be eaten merely as makeshifts.

Following are the insects identified in the stomachs of the grosbeak:

COLEOPTERA.

Platynus variolatus.
Rhizobius ventralis.
Psyllobora taedata.
Megapenthes elegans.
Buprestis fasciata.
Podabrus sp.
Telephorus consors.
Telephorus divisus.
Telephorus sp.
Aphodius rugifrons.
Aphodius sp.
Leptura militaris.
Syneta albida.
Gastroidea cyanea.
Gastroidea sp.
Lina scripta.
Diabrotica soror.
Diabrotica trivittata.
Blapstinus sp.
Deporaus glastinus.
Scythropus californicus.
Dorytomus hispidulus.
Baris sp.
Balaninus sp.

HEMIPTERA.

Saissetia oleæ.
Lecanium pruinosum.
Lecanium corni.

LEPIDOPTERA.

Carpocapsa pomonella.

HYMENOPTERA.

Apis mellifera. ♀

DIPTERA.

Borborus sp.

Vegetable food.—Cultivated fruit amounts to 23 percent of the grosbeak's food for the six months that it stays in the North. None was found in the stomachs taken in April, but in all other months there was a good percentage. Cherries appear to be the favorite fruit, as they were contained in 42 stomachs. Figs were identified in 24 stomachs, blackberries or raspberries in 23, strawberries in 2, apricots in 1, and prunes in 1. Fruit pulp, not further identified, but probably of the larger kinds, was found in 25 stomachs. During cherry season these birds were almost constantly in the trees eating cherries. They do not appear to attack apricots, peaches, and prunes so extensively, but they feed freely on figs later in the season. Blackberries and raspberries are taken whenever possible, but mostly in July and August, after cherries are gone. There is no denying the fact that the grosbeak eats much fruit, and of the best kinds. Wild fruit amounts to something over 5 percent. All of it was eaten in the four months from May to August inclusive, but principally in July and August. The only wild fruit identified was the elderberry (*Sambucus*), which constitutes the bulk of this item, and was found in 26 stomachs.

Seeds of various weeds and some grain constitute 14.7 percent of the food. Oats were found in 9 stomachs and wheat in 7, but the amount was insignificant. The rest of the vegetable food consists of the seeds of more or less troublesome weeds, of which the grosbeak eats a very considerable quantity. The following is a list of the species identified and the number of stomachs in which each was found:

Milk thistle (*Silybum marianum*)	5
Nightshade (*Solanum nigrum*)	1
Bur clover (*Medicago lanceolata*)	2
Poison oak (*Rhus diversiloba*)	1
Sumac (*Rhus sp.*)	1
Alfilaria (*Erodium cicutarium*)	12
Geranium (*Geranium dissectum*)	13
Dwarf mallow (*Malva rotundifolia*)	1
Red maids (*Calandrinia menziesi*)	6
Rough pigweed (*Amaranthus retroflexus*)	3
Chickweed (*Stellaria media*)	13
Knotweed (*Polygonum sp.*)	2
Sorrel (*Rumex acetosella*)	1
Unidentified	24

Food of young.—Among these stomachs are those of 17 nestlings, varying in age from 2 to 8 days. The youngest brood, composed of 3, had been fed entirely on beetles, Hymenoptera, and caterpillars. For convenience, codling moth pupæ may be separated from other caterpillars. The average percentage of each was as follows: Beetles 0.7, Hymenoptera 0.7, caterpillars 92.3, codling moth pupæ 6.3. Note the large percentage of soft food in the shape of caterpillars and pupæ. Broods 2 and 3 were composed of 3 and 4 nestlings respectively, and were probably about 1 day older than brood 1. Their stomachs were entirely filled with animal food, divided as follows: Beetles 15 percent, caterpillars 55.4 percent, codling moth pupæ 23 percent, scales 2.6 percent, and other insects and spiders 4 percent. These nestlings had been fed with hard beetles to a much greater extent than brood 1, although only 1 day older. Brood 4 was composed of 4 nestlings about a week old. They had been fed on animal matter to the extent of 96 percent to 4 percent of vegetable. The animal food was divided as follows: Beetles 67.6 percent, Hymenoptera 3 percent, caterpillars 2 percent, scales 20.7 percent, and eggshells 2.7 percent. The vegetable matter consisted of hulls of seeds and rubbish. The increase in beetles and other hard food and the decrease in caterpillars in the diet of this brood, as compared with the younger ones, is very marked. Brood 5 contained 3 young, estimated to be 8 days old. These had been fed entirely on animal food, made up of the following elements: Beetles 82 percent, Hymenoptera 10 percent, scales 6.3 percent, larvæ 3.3 percent, insects' eggs 1.7 percent, and spiders 2.7 percent. Another increase in the hard elements of the food over the last is seen here, although the difference in age is presumed to be only a day.

Observations were made upon the feeding of nestling grosbeaks, but the results are not remarkable. A nest of 3 young, estimated to be about 3 days old when first seen, was watched for one-hour periods for several days. The number of feedings varied from 2 to 4 per hour. In this respect the grosbeaks much resemble the California towhee. Like that bird they evidently collect a lot of food and then supply all the nestlings by regurgitation.

SUMMARY.

In summing up the economic status of the black-headed grosbeak, the fact that it eats a considerable quantity of orchard fruit can not be ignored. That this fruit is taken from the ripening crop on the tree is also true. This, however, is the sum total of the grosbeak's sinning. It eats but few useful insects and practically no grain. To offset its fruit eating, it eats habitually and freely the black olive scale, the codling moth, and the 12-spotted diabrotica, three pests of California fruit culture. Comparatively few complaints have been made against this bird by orchardists, and its depredations are not believed to be serious. Should it ever become so plentiful as to cause serious loss, no attempts should be made to destroy the bird, but attention should be directed to devices for protecting the fruit, thus leaving the bird to continue its good work in the destruction of insects. So active an enemy of insect pests as is this grosbeak can not well be spared, especially in view of the possibility of an invasion of the State by the Colorado potato beetle.[a]

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[a] For further information on the food of the grosbeak, see Bull. 32, Biological Survey, Food Habits of Grosbeaks, by W. L. McAtee, 1908.

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